SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1922.

GENERAL PHYSICS.

2038. *Capillary Flow, Diffusion and Displacement.* **L. Lumière.** (Comptes Rendus, 174. pp. 1096–1101, April 24, 1922.)—Various devices are described by means of which photographic plates may be washed free from fixing material, solid substances may be extracted or precipitates washed, the water or other liquid being drawn through the substance by capillary suction through a strip of fabric or absorbent paper. T. H. P.

2039. *The Measurement of Absolute Viscosity; a Source of Error.* **F. M. Lidstone.** (Phil. Mag. 43. pp. 354–357, Feb., 1922.)—Gives an amended Poiseuille equation which takes into consideration the error caused by using the mean head in measurements with an absolute viscometer. When the difference between the initial and final heads is at all large as compared with the mean head the error is far from negligible. L. H. W.

2040. *Determination of Surface Tension from the Maximum Pressure in Bubbles.* **S. Sugden.** (Chem. Soc., J. 121. pp. 858–866, May, 1922.)—The values obtained for the surface tensions of many common liquids by different observers using the maximum bubble pressure method not only differ among themselves, but are not in agreement with the results yielded by other methods, such as that in which capillary rise is measured. The causes of these discrepancies are principally as follows: (1) If the liquid has a finite angle of contact with glass, the maximum bubble pressure method, which is independent of the contact angle, will give the true surface tension, whilst the method of capillary rise will furnish lower values equal, for small tubes, to the product of the surface tension with the cosine of the angle of contact. (2) Inaccurate knowledge of the surface tensions of the liquids used for purposes of comparison. (3) The assumption that the surface tension is proportional to the pressure required to liberate bubbles from a given jet is not strictly accurate, but with the small tubes usually employed the error thus introduced is very small. (4) With the maximum bubble pressure method it is usually necessary to correct for the curvature of the larger surface of the liquid, since with most liquids the central portion of the meniscus has a negligible radius of curvature only when tubes several centimetres in diameter are used.

It is not easy to deal mathematically with the form of the surface of a liquid in a tube of circular cross-section with another tube placed at its axis, but the difficulty may be overcome in a manner similar to that employed by the author with the method of capillary rise [Abs. 472 (1922)]. If two tubes of different radii are immersed to the same depth in a liquid and the pressure required to liberate bubbles from each is measured, the surface tension may be calculated from the difference between these pressures. The relationship between the capillary constant of the liquid, the radius of the tube, and the maximum pressure in the bubble is worked out for tubes up to several millimetres in diameter, and a simple form of apparatus devised which gives, for the surface tensions of water and benzene, values in satisfactory agreement with those obtained by the method of capillary rise. T. H. P.

2041. *Surface Tension of Mixtures of Alcohol and Water at 25° C.* **L. L. Bircumshaw.** (Chem. Soc., J. 121. pp. 887–891, May, 1922.)—Experimental precautions observed in the determination of the surface tension of mixtures of water and alcohol are described in detail and a full range table of results is given for the constant temperature of 25° C. The curve given by these results when plotted does not show the sharp point of inflexion observed by Firth at the concentration 4·47 % water. A. B. C. L.

2042. *Rigidity of Jellies.* **F. Michaud.** (Comptes Rendus, 174. pp. 1282–1284, May 15, 1922.)—It is shown that, if a slight difference of pressure, P, is maintained between the ends of a horizontal tube of length l and internal radius R filled with a jelly, the modulus of rigidity of the latter is given by the expression, $\mu = \frac{PR^2}{4Xl}$, where X represents the displacement of the molecules at the axis of the tube. If a few grains of gamboge are suspended in the jelly, X may be easily measured by means of a micrometric microscope. Measurements have been made in this way on 15 aqueous gelose solutions ranging in concentration from 0·04 to 0·6 per cent., the temperature being kept at 14–15° and three different tubes being employed. If the jelly is softened by subjecting it to alternate slight variations in pressure, the subsequent deformations are highly elastic. The jelly is, however, liquefied in parts if the difference in pressure applied exceeds a certain limiting value. The values of μ for jellies of different concentrations lie on a smooth curve, and the variation with the concentration is given by the empirical formula, $\mu = 6\cdot32(c - 0\cdot39)^{3\cdot3}$, μ being expressed in C.G.S. units and c in grammes of gelose per 1000 grammes of the aqueous solution. T. H. P.

2043. *Torsion of Solids of Revolution.* **T. Pöschl.** (Zeits. Math. u. Mechanik, 2. pp. 137–147, April, 1922.)—A report containing the known solutions of the problem of torsion of rods of variable circular section. Exact solutions are given for the cone, sphere, ellipsoid, hyperboloid (of one sheet), and paraboloid. Approximate solutions of the technically important cases of a shaft with a central hole for a portion of its length, the region near a sudden change of section of a shaft, and a shaft with a semicircular groove, are given. W. G. B.

2044. *Work Done in the Progressive Compression of Metals; Copper and Brass.* **F. Doerinckel.** (Zeits. f. Metallkunde, 14. pp. 189–194, May, 1922.)—Considerations based upon previous work [Abs. 658 (1922)]. For a perfectly-plastic (not cold-hardened) material the resistance W which a cylinder opposes to reduction of height should always be proportional to its base F, so that $W/F = p$. As long as the reduction in height does not much exceed 50 %, the formula for the work done in progressive compression would be of the type of formula for the isothermal compression of a gas. Cold-hardening alters the conditions; but the author arrives at a simple formula which is confirmed by the data of the previous work and which is found to reduce to the Boyle-type formula for copper at 700° C. and for some of the brasses at temperatures between 300° and 400° C. H. B.

2045. *The Tensile Strength of Metals. Mechanics of its Test.* **F. Körber.** (Stahl. u. Eisen, 42. pp. 365–370, March 9, 1922. Am. Soc. Mech. Eng., J. 44. pp. 392–393, June, 1922.)—When stress is plotted both against elongation and against area-reduction, the two curves are not the same, but show the same maximum stress. It is customary to refer the load on the basis of the initial cross-section f_0 of the test piece; but that f_0 no longer exists at the moment when the max. stress is being applied, and the load should be referred to the minimum cross-section; instead of tensile stress $\sigma = P/f_0$ we should then have "true stress" $\sigma' = P/f$. When σ' is plotted against the reduction in area, the values will, in the region of the greater deformation of the material, lie along a straight line. This had been shown by Möllendorff and Czochralski in 1913, and later by the author, and such curves are now given for five carbon steels and copper. For the region of pronounced plastic deformation the "Verfestigung (strengthening) rule" holds: the increase of stress is proportional to the alteration of shape expressed by the reduction of area. If the initial area $f_0 = 1$, then the stress σ referred to unit initial cross-section is a product of the true stress σ' and the area $f = (100 - q)/100$. While the f decreases gradually (straight-line rule) until it reaches zero value corresponding to a reduction of area $q = 100$, the σ' gradually rises from zero and follows, for the region specified, likewise a straight-line rule. A formula is deduced for the $\sigma_{\max.}$ from which the constants for the straight-line portion of the curve can be found. Observed and calculated values are in good agreement, and the considerations of Möllendorff and Czochralski are given a general basis.

In the second part of the paper the author develops a theory of the mechanics of the tensile test after Tammann's displacement of single crystallites along slip planes under maintenance of the crystal lattice. The slip planes are planes of low shear strength; the stress required to produce slip is lowest when the angle between the plane and the direction of stress is 45°. The few crystallites at this angle will first undergo plastic deformation; at higher loads other, so far protected, crystallites will be deformed, and the load required for further deformation will increase though the number of crystallites bearing the load becomes smaller. Finally all the crystallites will flow simultaneously (Tammann's flow stress) coinciding with incipient contraction. We know, however, that the strength further increases locally, proportional to the deformation; that is ascribed to a torsion of the crystallites into planes in which higher stress is required to produce slip. Rupture ensues when the cohesive force is overcome. These views are supported by references to the recent experiments on the crystallographic structure of worked metals, drawn wire, etc. [Abs. 1084 (1921) and 1182 (1922)], as revealed by X-ray examination. Space-centred lattices (iron, tungsten, molybdenum) become fibrous in the direction of the diagonal of a face of the elementary cube, face-centred lattices (copper, aluminium) in the direction of a cube diagonal or a cubical edge. **H. B.**

2046. *Photographic Determination of Trajectory.* **L. Dunoyer.** (Rev. d'Optique, 1. pp. 65–75, Feb., and pp. 105–120, March, 1922.)—Describes a method for the determination of the trajectory of a projectile by the use of two synchronised cameras. These cameras are described and illustrated in the paper which also gives a theory of the method, and reproductions of records obtained by it, on various shells provided with tracers. **J. W. T. W.**

2047. *Manifold Coupling of Vibrations.* **A. Kalähne.** (Zeits. techn. Physik, 3. 6. pp. 209–214, 1922.)—In the theoretical treatment of coupled vibrations it has been usual to consider only one type of coupling. It is here shown that three types, and mixtures of any two, may be considered. These types may be called acceleration coupling, resistance coupling, and position (or force) coupling, according as they affect in the differential equation of motion the terms involving the acceleration, the velocity, or the position of that which vibrates. If all three types of coupling are present the differential equations of motion are written:

$$\left.\begin{aligned}\frac{d^2x_1}{dt^2} + 2\delta_1\frac{dx_1}{dt} + n_1^2x_1 + \rho_1\frac{d^2x_2}{dt^2} + 2\delta_1\sigma_1\frac{dx_2}{dt} + n_1^2\theta_1x_2 = 0\\ \frac{d^2x_2}{dt^2} + 2\delta_2\frac{dx_2}{dt} + n_2^2x_2 + \rho_2\frac{d^2x_1}{dt^2} + 2\delta_2\sigma_2\frac{dx_1}{dt} + n_2^2\theta_2x_1 = 0\end{aligned}\right\}$$

After the general theory has been developed three special cases are treated, viz. (1) Acceleration and Resistance coupling, (2) Resistance and Force coupling, and (3) Acceleration and Force coupling. The last seems to be specially applicable and valuable. **E. H. B.**

2048. *The Development of the Laminar Velocity Distribution in a Tube, and its Significance in the Measurement of Viscosity.* **L. Schiller.** (Zeits. Math. u. Mechanik, 2. pp. 96–106, April, 1922.)—When liquid is flowing through a tube, there is a transition region extending for some distance from the orifice, in which it is settling down to the Poiseuille "parabolic" velocity distribution. Prandtl's "transition layer" theory is applied to the determination of the extent of this region, and the increase in the resistance occasioned thereby. The result is that the pressure head must be reduced by 1·08 times the average kinetic energy per unit volume of the issuing stream, before inserting it in the Poiseuille formula. Good agreement with experiment is obtained over a considerable range of Reynolds' number. **W. G. B.**

2049. *Computation of Electric Wave Propagation, Transmission Line Phenomena, Optical Refraction, and Inverse Hyperbolic Functions of a Complex Variable.* **G. W. Pierce.** (Am. Acad., Proc. 57. pp. 175–191, April, 1922.)—This paper provides a table of the values of $f(h)$ and $g(h)$

for numerical values of h from 0 to 250 where $f(h)$ and $g(h)$ are defined by

$$f(h) = +\sqrt{\frac{+\sqrt{1+h^2}+1}{2}}$$

$$g(h) = +\sqrt{\frac{+\sqrt{1+h^2}-1}{2}}$$

Methods of applying this table to extracting the square root of complex quantities, finding the inverse hyperbolic functions of a complex variable, calculating the attenuation and other constants of a transmission line and the index of refraction and extinction coefficient for waves in an absorbing medium, are given. W. H. G.

2050. *Terrestrial Gravitation.* **E. B. Lera.** (N. Cimento, 23. pp. 215–223, Feb.–March–April, 1922.)—A homogeneous sphere, under a flux of gravitation from each particle, this flux being absorbed by intervening matter after the manner described by Majorana, acts upon a unit mass at the surface as if the whole mass of the sphere were concentrated at its centre and as if the gravitational flux from the centre were absorbed by a thickness approximately equal to ¼ the radius of the sphere. On Majorana's (older) data, this would reduce the Newtonian attraction at the surface by about 1·8 per cent. A. D.

2051. *X-Ray Analysis of Structure of Lithium Compounds.* II. *Lithium-Hydride.* **J. M. Bijvoet and A. Karssen.** (K. Akad. Amsterdam, Proc. 25. 1 and 2. pp. 27–30, 1922.)—Using the Debye-Scherrer method an X-ray diagram of lithium-hydride has been obtained by means of K_{Cr} rays. LiH appears to crystallise regularly with 4 LiH per elementary cell (side $a = 4{\cdot}10 \times 10^{-8}$ cm.). The density is found to be $0{\cdot}76 \pm 0{\cdot}01$. On the basis taken for the calculation the following assumptions appeared to be most satisfactory:—NaCl structure with positive Li-ions and negative H-ions: systems of two-electron rings both round Li- and H-nuclei with radii respectively $\pm 0{\cdot}05a$ and $\pm 0{\cdot}6a$, the planes of which are normal to non-intersecting trigonal axes.

A. B. W.

2052. *New Method of Using X-Rays in Crystal Analysis.* **G. L. Clark and W. Duane.** (Nat. Acad. Sci., Proc. 8. pp. 90–96, May, 1922.)—The procedure described in this paper differs in some fundamental details from those methods of analysis developed by Laue, Bragg, and others. The substance to be examined may be in the form of a powder or of whole crystals. In the latter case a crystal having a volume of only 2·05 cubic m.m. is sufficiently large although the accuracy of the data obtained is a little greater if larger crystals are used. The method described employs X-rays belonging to a continuous spectrum and therefore containing a great variety of wave-lengths, and not the line spectra of definite wave-lengths, as in most other methods. An ordinary X-ray tube with a tungsten target may be used. As a rule the authors use the spectrum between 0·12 and 0·80 Å.U. In analysing a small crystal it is placed in the centre of the X-ray spectrometer provided with an ionisation chamber and a quadrant electrometer. Narrow slits are used and the best results obtained by turning the X-ray tube so that the rays to the spectrometer leave the target almost grazing its surface. The ionisation chamber is set so that the line from the axis of rotation to the slit makes an angle, 2θ, of convenient size (say 10°) with the direct beam of rays. Keeping the ionisation chamber always in the same position the crystal is turned by successive small steps and the corresponding ionisation currents measured. When a set of parallel planes in the crystal lie at an angle θ to the incident beam of rays the planes pick out of the beam X-rays of certain definite wave-length λ and reflect them into the chamber, a marked increase in ionisation current being observed. Evidently the angles between the positions of the crystal that correspond to the maximum ionisation currents are the angles between the crystal planes. An accuracy of $\pm 0{\cdot}01°$ is obtained easily by this method. Examples of this are given.

If the specimen to be examined is in the form of a powder, it is placed at the centre of the spectrometer, the ionisation chamber fixed at angle 2θ as before, and the voltage is reduced by steps and corresponding ionisation currents determined at each step. The ionisation current vanishes when the voltage is no longer able to produce the longest X-rays that are reflected at the angle θ by the powder. In addition to the point where the ionisation current vanishes there are several well-marked places where the curvature changes abruptly. The voltages at these breaks in the curve are those at which the rays reflected from other crystal planes cease to be produced. These voltages, together with the angle θ, substituted in the equation

$$d = \frac{12354}{2V \sin \theta}$$

give the corresponding distances between the planes. A. B. W.

2053. *Refraction Equivalents of Ions.* **J. A. Wasastjerna.** (Öfvers. Finska. Vet. Soc. 63 (A) No. 4. [18 pp.] 1921. Chem. Zentrbl. III. p. 759, 1921.)—Cuthbertson's rule for the relation between refraction equivalents of atoms and their position in the periodic system is applicable to the ions of the alkali and alkaline-earth metals. The outer sheath of electrons contains, in the alkali metals, only one electron which in the salt has passed into the acid half, so that the rest becomes negative. In the alkaline earths there are two such electrons. The next sheath in either of these groups is identical with that in the preceding member of the horizontal series which, owing to the greater attraction, is nearer to the nucleus.

H. B.

2054. *Theory of the Resistance Limits in Mixed Crystals.* **G. Masing.** (Zeits. anorg. Chem. 118. pp. 293–308, Sept. 13, 1921.)—Tammann's suggestion that there is no diffusion and no exchange of position of the atoms in solid bodies would signify that the thermodynamic standpoint must, for solids, be replaced by an atomistic standpoint. Experimentally Tammann supports this suggestion by the observation of reaction limits. The author accepts the conclusion. But he shows mathematically that it is not necessary to assume with Tammann that the atoms must be regularly distributed in the space lattice in order to explain the resistance limits. An irregular distribution would, on the laws of probability and on certain assumptions, also account for the resistance limits and the existence of coherent atomic threads. That the calculations made by the author for Ag_2S do not agree with experimental data may be due to his arbitrary assumptions. In any case the author does not consider he has disproved Tammann's supposition of a regular distribution; that might be done by Röntgen analysis. H. B.

2055. *Magnetic Moment of the Silver Atom.* **W. Gerlach and O. Stern.** (Zeits. f. Physik, 9. 6. pp. 353–355, 1922.)—From the experiments previously described [see Abs. 1009, 1010, and 2121 (1922)] it is possible to calculate the magnetic moment of the silver atom. The results show that the magnetic moment of the normal silver atom in the gaseous state is that of a Bohr magneton. A. W.

2056. *Quantum Mechanism in the Atom.* **E. T. Whittaker.** (Roy. Soc. Edinburgh, Proc. 42. 2. pp. 129–142, 1921–1922.)—Considers an electron approaching a neutral atom at a speed insufficient to ionise it but sufficient to evoke a single-line spectrum. The field must then be electric, since there is change in the kinetic energy of the electron, and evoked by the electron. And the electron is repelled, so mechanisms involving attraction are excluded, *e.g.*, a group of permanent electric dipoles pivoted at centres, in equilibrium when the atom is isolated, but setting up an electric field (attractive) when disturbed by the approach. But this would be the electric analogue of the grouping of small magnets within the atom by which Ewing explains induced magnetisation in paramagnetic bodies [see Abs. 1722 (1922)], suggesting the electric analogue of the mechanism of induced magnetism in diamagnetic bodies, viz. that the approach of the electron induces within the atom the magnetic analogue of an electric current. Suppose, then, a group of bar magnets rigidly connected like wheel spokes, to be set in rotation as a whole by the approaching electron. This, which may be called a magnetic current, is shown to lead to differential equations indicating that unless the initial energy attains a given minimum, the electron gives up no energy to the magnetic structure but experiences simply an elastic impact; if, however, the initial energy is greater than this amount, it gives up this amount only, retaining the rest. The author observes that this "magnetic current" is equivalent to an "electric shell," which latter as to all intents what is called a charged condenser in electrostatics, so that the "magnetic current" is the equivalent of a charged condenser in the atom. Now a great body of evidence points to something in the nature of a Hertz oscillator, which is simply a discharging condenser, as the radiating element in the atom. The charge on either plate of the condenser is found to be simply e, the electronic charge; so the effect of the collision is to displace one electron in the atom from its normal position, and the vibrations which generate the emitted radiation are the vibrations of this electron settling down again to its normal position: this agrees with the generally accepted view of line-spectra production. It seems difficult to see how atomic oscillations can be generated unless there are two factors playing the parts in the differential equations that capacity and inductance play in the equation of oscillatory discharge of a condenser, and the assumption of their presence leads to the conclusion that:—(1) The existence of a natural constant of action simply indicates that the Hertzian oscillators in the atoms are similar to each other in structure and differ only in scale. (2) The frequency of the emitted radiation is related to the amount of kinetic energy absorbed from the bombarding electron by Planck's equation. In later additions, after discussions, the author :—(1) Offers an alternative model in which a perfectly conducting linear circuit is linked with the magnetic structure so that the energy is alternately that of a "magnetic current" and an electric current. (2) Indicates the interpretation of photoelectric phenomena. (3) Explains how the energy set free by the fall of an electron from an outer Bohr orbit to an inner one is transformed into radiation of frequency determined by Planck's equation $h\nu = \mathrm{U}$, and leads to the well-known formula for the series lines of the H spectrum.

J. A. Ewing. (*Ibid.*, pp. 143–146.)—Whittaker's "magnetic current"—set up by a non-elastic encounter—is unidirectional, and is equivalent to a charged condenser simply, not to one undergoing Hertz oscillations. In a note to his paper referred to above, after conversation with Whittaker, the author suggested that the quantum of radiation might be determined by the definite amount of work (say U′) expended in causing the wheel to break away from one stable position and fall into another. In Whittaker's more convincing view work U is done in traversing the system. U′ would probably be greater, perhaps much greater, than U, so that the passing electron would merely produce oscillation about the original stable position. Whittaker's equations show the electron giving angular momentum to the atom and losing linear momentum along the axis. Assistance of the ether seems requisite for conservation, and even for angular momentum equal for electrons leaving one atom and entering another it seems necessary to think of the ether as storing the momentum during the transit. The emission of an electron being associated with angular oscillations means association with radiation, so that the theory should have a bearing on photo-electricity.

H. S. Allen. (*Ibid.*, pp. 213–220).—Whittaker's magnetic structure may be called a *magneton*, using that term in its widest sense, and the general arrangement of the lines of magnetic force therein is not unlike that due to two anchor rings, McLaren or Parson magnetons, placed near together with planes parallel and having a common axis, and a model based on this might possibly be found, eliminating the difficulty of the passage of the electron through the matter of the bar magnets. Referring to Whittaker's suggestion that his magnetic model might be dropped, once the differential equations were obtained, the author claims that careful examination of his paper shows some form of magnetic element is required both for the absorption of energy by the atom from the electron and for the transformation of the absorbed energy into the radiant form. Moreover, Whittaker's *calamoids*—four-dimensional tubes of electromagnetic force [Abs. 1352 (1922)]—include as particular cases both kinds of Faraday tubes (electric and magnetic), and treat magnetic forces as on equality with electric. The author argues that the calamoid concept leads to the view that the world of events is not a continuum, but is built up of individual tubes of force of this complex character; and it must surely be necessary to retain discrete tubes of magnetic induction in three dimensions, and therefore the *magneton*. The admission of a natural constant of action in Whittaker's present paper, moreover, involves departing from classical theory and postulating a vibrator which does not lead to the law of equipartition of energy.

R. A. Houstoun. (*Ibid.*, pp. 221–222.)—The author, to check Whittaker's model, numerically calculates the approximately magnetic orbit on simple assumptions with satisfactory agreement with observation. In the simplest case Planck's constant comes out as the product of unit electric charge and a unit magnetic quantity, the correct dimensions. Hitherto, we have always assumed that the play was between kinetic energy of moving electrons and electrostatic potential energy. Apparently the latter must now be replaced by the kinetic energy of moving magnets: potential energy disappears from the scheme. At the same time the reciprocity which exists between electric and magnetic quantities in the electromagnetic wave must be extended to atomic structure. The new quantum mechanism is of the highest importance both for the vistas it opens out and the salutary influence it will exert on some of the more speculative theories of radiation. G. W. DE T.

2057. *The Importance of Reduced Orthogonal Coordinate Systems for Tensor Analysis and the Special Theory of Relativity.* **P. Gruner.** (Zeits. f. Physik, 10. 4. pp. 236–242, 1922.)—This paper, which is entirely mathematical, shows that all the relativity relationships considered can be simply regarded as special cases of the general relationships between covariant and contravariant coordinates. H. H. Ho.

2058. *On the Electromagnetic Field of Bohr's Stationary Trajectories.* **E. Bauer.** (Comptes Rendus, 174. pp. 1335–1338, May 22, 1922.)—This paper contains a discussion of Bohr's atom from the standpoint of the quantum hypothesis. It is found that if Bohr's stationary trajectories emit no waves, their fields at a great distance should be constant. The quanta therefore have the effect of producing a permanent condition at a certain distance from the atom consisting of an organisation of lines of force in invariable tubes analogous to stationary turbulence in hydrodynamics. These conclusions are found to have special importance from the standpoint of our conception of the magnetic field, the latter not being distinguished essentially from the electric field in the relativity theory. The theory of quanta is now seen to afford it a distinct physical reality, consisting of stable tubes of induction which are multiples of a unit tube corresponding to the magneton. Unfortunately, however, the magneton, as evaluated, is equal to about 5 times the experimental value. These hypotheses are lastly employed to depict the field distribution in an atom of hydrogen, this appearing to consist of 3 parts, viz. an electronic field of fairly known conditions, an intermediate zone entirely unknown at present, and, finally, beyond a given distance, the region of constant field. The methods of celestial mechanics appear to the author as incapable of application to interatomic dynamics. H. H. Ho.

2059. *Gravitation Theories of Newton and of Einstein.* **P. Painlevé.** (Comptes Rendus, 174. pp. 1137–1144, May 1, 1922.)—The axioms of classical mechanics are:—(1) Natural solids which, when kept under conditions such that their relative dimensions are constant, wherever compared, correspond to the invariable figures of Euclidean geometry; (2) Newton's first law; (3) Fresnel's principle, the uniform rectilinear path of light in space. (1) Involves the definition of time once for all and for every point in space. Newton's gravitation.—Let $P \equiv (x, y, z)$ be an element of mass having immobile matter only in its vicinity. Its trajectories will be geodesics of a ds^2 of the form $(U + h)(dx^2 + dy^2 + dz^2)$

$\equiv (U + h)d\sigma^2$, where h is an arbitrary constant, U is a function of x, y, z, satisfying the Laplace-Clairaut equation everywhere and vanishing at infinity, and $d\sigma^2$ is an infinitesimal ds^2. Then, in other than rectangular co-ordinates, $d\sigma^2 = \sum a_{jk} dx_j dx_k (= 1, 2, 3)$ . . . (I), U becomes $U_1 (x_1, x_2, x_3)$, $d\sigma^2$ being Euclidean and U_1 is invariant for all coordinate transformations. If, *e.g.*, the masses assume geometrical and mechanical symmetry of a sphere with centre O, the trajectories of P will be the geodesics of $ds^2 = (\mu/r + h)\left\{dr^2 + r^2(\sin^2\theta d\phi^2 + d\theta^2)\right\}$, r, θ, ϕ being the polar coordinates of the space Oxyz. The measurements of length and time here implied are imperfectly realisable, observation giving only coincidence of phenomena at an identical place and time, which is unchanged by change of the coordinates x, y, z, t. Hence the search for invariant equations in mechanics, especially in gravitation problems. In a motion of P, or light ray, in the absence of matter, $ds^2 = c^2dt^2 - dx^2 - dy^2 - dz^2$ transforms into $ds^2 = \sum A_{jk}(x_1, x_2, x_3, x_4)\, dx_j dx_k\, (j, k = 1, 2, 3, 4)$ when the A_{jk} satisfy the classical conditions. Hence, whatever the reference system, in the absence of matter, movements of P are defined by geodesics of a Euclidean ds^2 and light paths by the geodesics along which $ds^2 = 0$. This follows from (2) and (3), but is equivalent to them only if x_4 is the time, and $\sum dx^2$ the square of an infinitesimal distance measured by a material metre. Hence, axiom (4), The motion of a material point, in presence of matter, subject only to gravitation is defined by the geodesics of a ds^2 of the above form, in which the A_{jk} satisfy a system of invariant conditions for all changes of x_1, x_2, x_3, x_4 and light paths are the geodesics for which $ds^2 = 0$. When the matter is all far removed from P_1 the analogy of Newtonian mechanics, leads us to assume, further: that these conditions must be partial differential equations of the second order, linear in the second order derivatives; and that they must leave to the A_{jk} the exact indetermination appropriate to the problem. The A_{jk} then become Einstein's *gravitation potentials*. For immobile masses only, and if x_4 represent time we have the further axioms: (5) The ds^2 does not contain t explicitly (Principle of causality); and (6) the ds^2 does not change when t is replaced by $-t$ (Principle of reversibility). Then, necessarily $ds^2 = dt^2/U(x_1, x_2, x_3) - d\sigma^2 (U > O)$ . . . (II), where $d\sigma^2$ is of form (I), but is no longer Euclidean. Then, by Hamilton's principle, the trajectories of P are given by the geodesics of $ds_1^2 = (U + h)d\sigma^2$, h being an arbitrary constant, and t by $dt = Ud\sigma/(U + h)^{\frac{1}{2}}$. The light paths are therefore given by $dt = d\sigma\sqrt{U}$. Axiom (3) now holds only far from matter, and, so modified, enters into (4). But (1) still holds. When the matter has complete spherical symmetry ds^2 now assumes the Schwarzschild form $(c = 1)ds^2 = (1 - 2\mu/\rho)dt^2 - \rho^2 (\sin^2\theta d\phi^2 + d\theta^2) - dr^2/(1 - 2\mu/\rho)$, where μ is a constant, shown to be positive and approximately equal to the Newtonian gravitation constant, by comparing Kepler's laws with Newton's gravitation law, and ρ is an unknown function of r, except that it becomes infinite with r, and differs little from r except near the boundaries of our solar system. The author calls the theory here developed the semi-Einstein gravitation theory, and mentions that, in the absence of a more exact knowledge of the major axes of the planetary orbits, its consequences are astronomically indistinguishable from those derived from the Schwarzschild equation. The change over to Einstein's theory may be effected by replacing (1) by (1_a), viz. when the ds^2 of gravitation has the form (II), t being the time, $d\sigma$ measures the distance between two infinitely near points. If then the shortest distance measured by a material metre between any two points assumed to be fixed in the ether be defined as a geodesic of $d\sigma^2$, it will follow that the neighbourhood of matter will influence the geometrical properties of natural solids. G. W. de T.

2060. *The Astronomical Verifications of Einstein's Gravitation Theory.* **J. Chazy.** (Comptes Rendus, 174. pp. 1157–1160, May 1, 1922.)—Einstein has proposed to replace the equations $G_{\mu\nu} = 0$ by the equations $G_{\mu\nu} - \lambda g_{\mu\nu} = 0$, where λ is very small, being $1/U^2$, U being the radius of his cylindrical universe. For de Sitter's spherical universe, the value would be $3/U^2$, U being its radius. The author finds that the ds^2 of Schwarzschild would become $ds^2 = (V^2 - 2\mu/r - \lambda V^2 r^2/3)dt^2 - dr^2/(1 - 2\mu/V^2 r - \lambda r^2/3) - r^2(d\theta^2 + \cos^2\theta d\phi^2)$, V and μ being constants of integration. The shift of spectral lines and the deflection of light rays will not be sensibly affected by the introduction of λ. The trajectory of a material particle will be plane and given by $(dr^{-1}/d\theta)^2 = A - (1/r^2 + B)(1 - 2\mu/V^2 r - \lambda r^2/3)$, A and B being integration constants, B having the value $ds^2/r^4 d\theta^2$. Putting $B = 0$ gives the path of a light ray. The term $6\pi\mu/V^2 a(1 - e^2)$ in the advance of planetary perihelia per revolution will be supplemented, in the case of small eccentricity, by $\pi\lambda a^4 B$, which sensibly equals $\lambda V^2 T^2/4\pi$. From planet to planet the secular advance due to the first term will vary, neglecting the squares of the eccentricities, inversely as $a^{5/3}$, or $T^{5/2}$, and for Mercury, Venus, the Earth, and Mars, will be to 42″·9; 8″·61; 3″·83; 1″·35: that due to the second term is proportional to T, the time of revolution. Tisserand has inferred, with some reservations, from the work of Le Verrier and of Gaillot, the possibility of a secular advance of Saturn's perihelion, of about 40″ beyond that indicated by Newton's law. Assuming this to exist and to be the result of the term $\lambda V^2 T^2/4\pi$, U may be inferred to be of the order of a thousand light years. Corresponding secular advances in perihelia might be inferred of 1″·34 for the Earth, 2″·46 for Mars, 16″ for Jupiter, 114″ for Uranus, 224″ for Neptune, and about 4″ and 100″, respectively, for the perihelia of Encke's and Halley's comets. These results may be regarded as corresponding fairly well with observation. If U were of a higher order these corrections would be too small for observation. It could not be of so small an order as 100 light years, for this would require secular advances of 100″ and 200″ in the perihelia of the Earth and Mars, respectively.

J. Trousset. (*Ibid.*, pp. 1160–1161, May 1, 1922.)—The author, with the object of answering the question raised by Painlevé [see preceding Abstract], whether it would be possible, from astronomical observations, to replace, in Einstein's ds^2, the radius vector r by a less simple function of r, investigates the deviations from Kepler's three laws which would result from the acceptance of Einstein's formulæ. His conclusion is that the difference between the Kepler and Einstein orbits would in no case be of a higher order than a kilometre, which at the planetary distances would not subtend an angle of more than 0″·001, and that, consequently, the only astronomical evidence in favour of replacing Newton's law of gravitation by that of Einstein is the accounting, by the latter, for the Mercurian anomaly.

P. Painlevé. (*Ibid.*, pp. 1161–1162, May 1, 1922.)—The author observes that the two preceding papers, which contain certain contradictions, notably in the case of Saturn's motion, show clearly the necessity

of an immense amount of work in investigating the amounts of the many minute corrections involved in the acceptance of Einstein's theory. He points out that Trousset's paper takes the point of view which he has termed the semi-Einstein theory, and which retains Euclidean geometry. For the complete Einstein theory the geometrical postulate (1_a) [see preceding Abstract] eliminates the arbitrary function of r. He points out that his estimate of an accuracy of the order of $0''\cdot001$ as being required in order that astronomical evidence other than that of the Mercurian anomaly, should be obtainable in favour of Einstein's theory is vitiated by his neglect of the possible effects, especially averaged effects, of the innumerable interactions within the solar system.
G. W. DE T.

2061. *A Graphical Representation of the Special Theory of Relativity in the Four Dimensional Space-time World. Part II.* **P. Gruner.** (Zeits. f. Physik, 10. 4. pp. 227–235, 1922.)—Part I of this investigation [see Abs. 30 (1922)], contained a set of examples showing the utility of the author's graphical method, and the present paper extends this applicability to reciprocal orthogonal coordinate systems. Section 1 considers the general transformation; Section 2, the suitable choice of admissible reference systems; Section 3, reduced and universal coordinates; Section 4, the representation of the special theory of relativity in reduced coordinates; and Section 5, relation to universal coordinates. The latter results were first obtained by E. Guillaume, but shown by D. Mirimanoff to have no universal physical significance, and the present author has been led to them by independent considerations. The paper is mathematical throughout.
H. H. Ho.

2062. *Unusual Halo Observed at New Haven, Conn., Feb. 25, 1922.* **C. S. Hastings.** (Monthly Weather Rev. 50. pp. 131–132, March, 1922.)—The phenomena presented on this occasion lead to the conclusion that the only effective ice-crystals present were very small, thin hexagonal plates of ice remaining steadily horizontal for a short period, and then evaporating. This is derived from a general theory of haloes due to the author [Abs. 611 (1921)] and the fact that the only well-defined portions of the halo visible were an unusually bright parhelion north of the sun (time 10.10 a.m.) and a portion of the parhelic circle on either side of it, lasting ten or fifteen minutes, and then in the S.W. a perfectly white, unusually large, paranthelion and a portion of the parhelic circle, both lasting only a few minutes. In the work cited above the author has contested the ordinary theory of the 46° halo. In this note he suggests an observational test of the validity of his criticism.
M. A. G.

2063. *Complex Solar Halo Observed at Ellendale, N. Dak.* **C. S. Ling.** (Monthly Weather Rev. 50. pp. 132–133, March, 1922.)—This halo, observed on Feb. 13, 1922, is noteworthy on account of the complexity of the phenomena manifested and the fact that it was produced by a thin cloud sheet which upper air observations showed to be in the neighbourhood of only 400 m. above the ground, associated with a temperature inversion of 0·5° C. in the region between a high and a low pressure system. Details are given of the component parts of the halo, their angular dimensions and the duration of each. These embraced a bright complete circumzenithal circle. The halo which formed at 10.52 a.m. did not end until 5.4 p.m. **M. A. G.**

2064. *High Level Isobars in Weather Service.* **R. Sekiguchi.** (Monthly Weather Rev. 50. pp. 242–243; Disc., 243, May, 1922.)—Describes the method adopted in Japan for drawing isobars for the 3-km. level, and gives a summary of the use of such isobars in predicting the travel of cyclones and anticyclones. **A. W. L.**

2065. *Vertical Distribution of Winds in Cyclones and Anticyclones.* **T. Molchanov.** (Monthly Weather Rev. 50. p. 244, May, 1922.)—The vertical distribution of wind is classified into the following groups:—A, where the wind direction turns to the right with increase of elevation. This is associated with a rise of temperature and occurs in the rear of an anticyclone or the front of a cyclone. B, where the wind direction remains constant with increase of elevation. This involves no change of temperature and occurs in the edges of an anticyclone or on the right of a cyclone. C, where the wind direction turns to the left with increase of elevation. This is associated with a fall of temperature and develops in cold waves from the north.

Observations at Dixon Island are given showing examples of the occurrence of these groups and giving the mean changes of pressure and temperature associated with each. **A. W. L.**

2066. *Directions of Magnetisation in Arctic Basalts.* **P. L. Mercanton.** (Comptes Rendus, 174. pp. 1117–1118, April 24, 1922.)—A contribution to the knowledge of the history of the earth's magnetic field. Specimens of basalt, of tertiary age, from Disco Island, West Greenland, were found to have south (seeking) polarity on their under surfaces and north on their upper surfaces. The direction of magnetisation in one of the basalts was at 54° to the horizontal, with the south pole lowest. A second series of basalts of modern formation, from Jan Mayen Island, were found to be magnetised in a direction which corresponded with that of the present-day earth's field in Jan Mayen, the lower faces of the basalt blocks having north polarity. The earth's magnetic dip appears to have changed sign in northern regions, and in connection with this, an examination of basalts from the Antarctic would be of interest. [See also Abs. 629 (1904).] **G. E. A.**

2067. *Deviation of Light Rays near a Heavenly Body.* **Ferrier.** (Comptes Rendus, 174. pp. 1404–1407, May 29, 1922.)—The heavenly body in question is the moon during a solar eclipse. The rays passing near the sun must also pass near the moon. Assuming a slight atmosphere of hydrogen, there should be a considerable modification of the Einstein effect, but practically none on lunar occultation. **W. W. B.**

2068. *Changes on the Moon.* **W. H. Pickering.** (Pop. Astron., May, 1922. Nature, 109. p. 690, May 27, 1922.—Review.)—Two drawings of the crater Eratosthenes, by Dr. Maggini, support Prof. Pickering's contention that changes noted are real and not due to the varying shadows, since they are visible at full moon, and one points towards the setting sun instead of away from it. But the incidence of the light is known to affect the reflecting power of substances, and it is generally agreed that the brightening of the bright streaks and the darkening of the floor of Plato are caused in this way. Pickering does not seem to have fully considered this point of view. He estimates the moon's atmosphere to have a density $\frac{1}{10}$ that of the earth, and thinks that enough water vapour and CO_2 might be emitted from the craters to support low forms of vegetation. W. W. B.

2069. *Spectrum of Chromosphere.* **P. Salet.** (Bull. Astronomique, 2. 5. pp. 349–360, 1922.)—This is the result of measurement of one of the photographs obtained by Millochau with the Great Coudé Equatorial of the Paris Observatory during the eclipse of April 17, 1912, with the slit placed at the point of the bright crescent. The photograph is very rich in bright lines, having 180 between λ3700 and 4600. In the table of wavelengths some are definitely marked *a* for atmosphere or *d* for disc, as well as being assigned to chromosphere or flash-spectrum. Some are noted as not occurring in the sun. It is pointed out that the partial phase, or an annular eclipse is most favourable for work of this kind. The lines marked *a* correspond to relatively strong absorption lines (Fe, Mg, Al) apparently produced by vapour below the photosphere. The lines marked *d* are of relatively feeble absorption (La, V, etc.). For the identification of doubtful lines more comparisons are necessary, bearing in mind that it is extremely unlikely that the flash-spectrum should show no variation in constitution of its layer at different times.

The two lines claimed by Hartley for Ga are shown but appear to belong to Mn and Ti respectively. Five or six strong lines of La are among those supposed not in the sun, but it seems likely that they do occur in the chromosphere, especially since Ba, whose atomic weight is of the same order, is certainly there. The three lines assigned by Dyson to Eu are all shown, but one is possibly Ni and another V. Many other indentifications are doubtful, such as Nd.

It is remarked that the pressure in the reversing layer must be very small, and yet enhanced lines appear there and are even more intense in the higher layers where presumably the temperature is lower. For instance, enhanced Fe lines occur in the chromosphere where the finest arc-lines are relatively weak. W. W. B.

2070. *Relationship between Solar Prominences and Corona.* **W. J. S. Lockyer.** (Roy. Astron. Soc., M.N. 82. pp. 323–330, April, 1922.)—Since the author's last paper on the subject [see Abs. 729 (1908)], two maxima and one minimum have occurred, and nine total solar eclipses. The additional data are now examined to bring the material up to date and test the conclusions previously suggested. The data used include prominence data, Corona data, giving a table of coronal forms from 1893 to 1919 and detailed comparison of prominence zones with forms of corona, the conclusion being strongly in favour of the intimate association between prominences and coronal matter. W. W. B.

2071. *Variable Star η Aquilæ.* **H. Grouiller.** (Bull. Astronomique, 1. 6. pp. 331–357, 1922.)—There have been successive attempts to fix the period and light-curve of this star, since its discovery in the eighteenth century. Schönfeld, Schur, and W. J. S. Lockyer have found periods of slightly different lengths and also not quite agreeing in the matter of secondary maximum and minimum. The late Luizet took a large number of observations and his successor has now been working them up in combination with previous sets, including 640 observations between 1899 and 1912 by members of the Variable Star Section of the British Astronomical Association, 540 by Moye at Montpellier, 1904 to 1917, and 1090 by Luizet at Lyons, 1897 to 1917.

He gives light-curves of Heis, Argelander, Luizet, Markwick, and Moye, of which that of Luizet, depending upon more observations, he considers the best. He discusses the differences between the values adopted for maximum and minimum by different computers. His finally adopted period is 7·176480 days, which is rather longer than those of Schönfeld and Schur. He finds a slight secondary maximum 53 hours after the principal one, following a secondary minimum by about 11 hours; the principal minimum being about 97 hours after the principal maximum. He adopts 3·65 m. and 4·47 m. as the actual magnitudes at maximum and minimum, but finds these to vary both in time and intensity. The accidental errors are too great to permit a complete analysis of the irregularities, which seem to be generally of the kind associated with Cepheid variables. W. W. B.

2072. *Disintegration of Comets.* **H. Svoboda.** (Bull. Astronomique, 2. 5. pp. 369–372, 1922.)—Lowell has computed separately the cases of circular, elliptical and parabolic orbits. The author gives a general method from which he obtains the condition of stability at any point:

$$\frac{m_3(3 + e\cos\phi)}{r_{13}^3} \leqq \frac{m_1}{r_{12}^3}$$

where r_{12} is the mean distance of the particles from the centre of the swarm, r_{13} that of the centre of the swarm from the sun, m_1 mass of swarm, m_3 mass of sun, e the eccentricity and ϕ the true anomaly in the comet's orbit round the sun. The effect of the eccentricity is not great, but the distance from the sun is important. The density of the nucleus for a comet with small perihelion distance must be great if disintegration is to be avoided. W. W. B.

2073. *On Geodesic Precession.* **J. A. Schouten.** (K. Akad. Amsterdam, Proc. 24. 8. pp. 1108–1112, 1922.)—In a previous paper the author showed that a system of axes moved geodesically along a closed curve in a non-Euclidean continuum, will show a deviation when returned to its starting-point. In the case of the motion of the earth round the sun, this deviation is 0″·013. Fokker, treating this as a four-dimension problem, found a geodesic precession fifty per cent. greater [see Abs. 794 (1921)]. The author explains this difference as being due to the restriction that the four-dimensional problem can only reduce to the three-dimensional one for particular cases when the square of the velocity is of the order of the fourth power of the ordinary velocity considered. He further points out the possibility mentioned by de Sitter that ordinary precession has a different value in relativist mechanics from that it has in classical mechanics; and that this deviation can be calculated from Fokker's four-dimensional equations, ignoring certain possible influences. W. W. B.

LIGHT.

2074. *Refraction of Light at Corresponding Temperatures.* **W. Herz.** (Zeits. phys. Chem. 98. pp. 175–185, July 27, 1921.)—According to C. Smith [Abs. 173 (1913)] all substances should have the same refractive index $n_c = 1 \cdot 126$ at the critical temperature for light of infinite wave-length. Smith had based his calculations upon 32 substances, 7 gases, and 25 liquids. Prudhomme came to the same conclusion. The author examines the data of various other substances, and inquires in particular whether the Lorenz-Lorentz formula $(n^2 - 1)/(n^2 + 2)\, d = (n_c^2 - 1)/(n_c^2 + 2) \,.\, d_c$ may be replaced by the simpler formula of Gladstone-Dale $(n - 1)/d = (n_c - 1)/d_c$, referring the index to sodium D light. In the case of 5 gases either formula answered; for HCl Gladstone-Dale was less satisfactory, but for most liquids either formula would give values within 1·9 % of the observed value. The n of all these liquids was, however, intermediate between 1·22 and 1·41; for n greater than 1·41 the deviation was greater, amounting to 10 % in the case of bromine, where $n_{15} = 1 \cdot 659$, to 10 %. H. B.

2075. *Optical Properties of Solutions. Structure of the Molecules of Electrolytes.* **J. A. Wasastjerna.** (Acta Soc. Sci. Fennicæ. 50. No. 2. [129 pp.] 1920. Chem. Zentrbl. III. pp. 758–759, 1921.)—The influence of the dissociation of electrolytes on the optical properties is studied by observing the density and index of aqueous solutions of organic salts, oxalic acid, KCl and NaCl at two temperatures for three λ. The number of valency electrons in an atom calculated from Eisenlohr's atomic refraction constant agrees with Drude's valency theory. A new interpretation of the Lorenz-Planck dispersion formula is given by which the photoelectric effect and, in certain cases, also the change in refraction and dispersion due to dissociation can be calculated. The temperature coefficient of the molecular refraction of dissolved gases is always negative by the Newton-Laplace formula, and also by the Lorentz-Lorenz formula; it may be either negative or positive, with average value zero, by the Gladstone-Dale formula, which on the whole gives the additive character of specific refractive power best. For the determinations of the molecular refraction the solution should be as concentrated as possible. In strong electrolytes the optical properties of salt solutions are best explained by the assumption that the ions are readily formed in the molecules.

H. B.

2076. *Interference Methods for Measuring Johansson Blocks.* **A. Pérard.** (Rev. d'Optique, 1. pp. 209–231, May, 1922.)—A method, due to the author and M. Maudet, of finding the length of a block by comparison with a line standard, consists in clamping a short divided scale to each end of the block and finding the distance between two given lines, first with the block in and then with it out. But the interference method mentioned consists in placing the block between two parallel plates, the upper one being glass so that a thin uniform air layer remains between the glass and the upper surface of the block and proceeding as in the usual Fizeau experiment to observe the fringes due to the air layer formed by monochromatic light. By using several kinds of monochromatic illumination, eight in all, whose values of λ vary from $640 \cdot 224\ m\mu$ to $435 \cdot 832\ m\mu$, the actual length required is evaluated by certain series formula quoted. The mean value of a block measured was $11958 \cdot 079\ \mu$. An apparatus for comparing three blocks set up between the parallel plates is also described and sketched. P. E. S.

2077. *Propagation of Light in Moving Transparent Solid Substances. III. Measurements on the Fizeau Effect in Flint Glass.* **P. Zeeman, W. de Groot, [Miss] A. Snethlage, and G. G. Dibbetz.** (K. Akad. Amsterdam, Proc. 24. 9. pp. 1402–1411, 1922.)—To obtain greater accuracy in measurements of the Fizeau effect in flint glass, improvements in the arrangement previously described [see Abs. 712 (1920)] in the account of the experiments with quartz are given in detail. The present modified experiments with flint glass are not regarded as productive of conclusive results. A. B. C. L.

2078. *Relation between Light-Absorption and Light-Scattering for Liquids.* **W. H. Martin.** (J. Phys. Chem. 26. pp. 471–476, May, 1922.)—The author has measured the transparency of dust-free water and benzene for wave-lengths 4358, 5461 and 5780 Å.U. The value found for the absorption of dust-free water is considerably less than that found by other observers, with the exception of the values given by Aufsess [Abs. No. 1624 (1904)]. The absorption is, however, still much too large to be accounted for by scattering alone. J. S. G. T.

2079. *The Physical Chemistry of Colour Vision.* **F. Weigert.** (Zeits. Phys. Chem. 100. pp. 537–565, 1922.)—A discussion is given of recent theories to account for the mechanism of colour perception in the eye, based on observations on the light-sensitiveness of colouring matters. According to the theory of Hering, in the light perceptive elements of the retina, specific changes are produced by the incidence of light through the co-operation of dissimilation and assimilation processes in media which are sensitive to black-white, red-green, and yellow-blue light excitation (caused by dichromatism through varying thicknesses of absorbing medium) and are separate from the light receptive body known as the visual-purple system. The theory at present put forward regards all these reactions as occurring in this last system. The diverse visual phenomena observed are also exhibited in simple light-sensitive systems with reagents of non-vital origin. The present work describes a large amount of experimental data and analogies in support of a basis common to visual and photochemical effects. Measurements with polarised light on collodion layers coloured with representatives of different colour classes in dilute condition show that at the beginning of excitation these coloured light-sensitive systems behave similarly to photochlorides in colour adaptation and allied phenomena. As in the eye, a change of state is brought about so that the system tends to adapt itself to become insensitive to the particular radiation applied, as is observed in bleaching.

Dichroic effects with photochloride collodion films after exposing to particular radiations were measured with a polarisation microscope and the coefficients of extinction were determined photometrically in different parts of the spectrum. The results are found to be in accordance with

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physiological measurements on light adaptation for different colours. It is concluded that in the eye the visual-purple is continually being regenerated so that a stationary colour concentration is obtained which is inversely proportional to the intensity of the light. The phenomena themselves which underlie the specific changes in light-sensitive coloured systems are not completely understood and have been attributed to the action in highly dispersed systems of electron movements caused by inner photoelectric effects. J. N. P.

2080. *Electro- and Magneto-Optics of Liquids Holding Metallic Powders in Suspension.* **S. Procopiu.** (Comptes Rendus, 174. pp. 1170-1172, May 1, 1922.)—Continuing previous work [Abs. 1414 (1921)] the author has found that all liquids holding metallic fine powders in suspension exhibit in an electric or in a magnetic field a negative double refraction, i.e., of the same sign as that shown by compressed glass along the lines of force. The following metals were used: Hg, Mg, Sb, Al, Cu, Fe, Ni, Cd, Zn, Bi. The double refraction does not disappear immediately when the field is removed except in the case of mercury. For all the other metals used there is a "relaxation" time of 2 or 3 minutes during which the double refraction persists. In a magnetic field different liquids give different results. In the absence of any magnetic or electric field all the liquid metallic powder mixtures exhibit a spontaneous positive double refraction, due probably to the fall of the metallic particles through the liquid. A. W.

2081. *Phototropy and Photoelectric Effect.* **P. H. Gallagher.** (Soc. Chim. de France, Bull. [iv] 29. pp. 961-976, Nov. 20, 1921.)—In a paper on Phototropy (*ibid.*, 29. pp. 683-696) dealing with various salicylidene amines, the author had shown that the change of colour on exposing to light cannot be explained by any atomic transformation in the molecule, and that there is no direct connection between colour and constitution. After the method of Padoa and Amaduzzi [Abs. 840 (1912)] he exposes solutions of various aldehyde amines placed on an electrometer plate to the rays of a quartz mercury lamp and observes the rate of discharge before and after exposure to sunlight (up to 49 minutes), which may or may not cause a colour change. There was always a photoelectric effect (colour change or not), and there was further fatigue, consecutive exposures having less effect; temperature has strong influence. Phototropy may be much more general than is believed, because we notice only visible changes, and the change is not chemical, i.e. explicable by formulæ. A body may appear in different colours without altering its structure. If an absorption band be produced by a peculiar arrangement of the electrons, a simple displacement of the electrons might produce a colour change. When the red modification of phenylhydrazone-benzaldehyde is placed on glass in a stove, the glass about the substance becomes phosphorescent; but this stops on cooling, to start on reheating. At ordinary temperature no luminosity is seen after exposure; but it sets in at 100°. When the same substance is placed on a photographic film and then heated to 50° for 20 minutes, the portions surrounding the spot turn black. No spectroscopic studies are mentioned. H. B.

2082. *On the Variations of the Critical Opalescence with Temperature and Wave-length of the Incident Light.* **A. Andant.** (Comptes Rendus, 174.

pp. 1333–1335, May 22, 1922.)—Reference is made at the outset to the work of K. Onnes and Keesom [Abs. 2057 (1908)], who were the first to record spectro-photometric measurements of the critical opalescence, the substance chosen being ethylene. The present paper deals with similar measurements under more varied conditions for 5 liquids viz:—ether, and methyl, ethyl, butyl, and isobutyl acetates. The method of filling the tubes has been described in a previous investigation [see Abs. 109 (1921)], and these are heated in an electric stove, whose temperature is recorded by Baudin's mercury thermometers and thermo-electric couples. The 5 liquids examined exhibit opalescence of great intensity, and measurements were made at falling temperatures. Section 1 deals with the influence of temperature. Opalescence commences at 3° above the temperature of reappearance of the meniscus T'_c, passes through a maximum at 0·05° of T'_c and vanishes at 0°·50 after the reappearance. The construction of curves representing the variation of the quantity of light absorbed with temperature allows the temperature of maximum opalescence to be accurately determined. The theory of Smoluchowski-Einstein which predicted the proportionality of opalescence to $(T-\theta)^{-1}$ has been verified, but only in the vicinity of 0·20° of θ, while other theories which require a proportionality to $(T-\theta)^{-2}$ should be completely abandoned. Section 2 describes the variation of opalescence with the wave-length of the incident light, this having been examined for the 4 visible lines of mercury (578, 546, 492, 436) and a red line near 635. The influence of the wave-length appears in two distinct but continuous phases. The law which holds up to 0·15° C. from the critical point is $I_{abs.} = A\lambda^{-4}$, but in the immediate vicinity is $I_{abs.} = B\lambda^{-2}$, as given by Ornstein and Zernike. H. H. Ho.

2083. *Photophoresis.* **T. Terada.** (Phys. Math. Soc. Japan, Proc. 4. pp. 67–70, April–May, 1922.)—F. Ehrenhaft and (afterwards) I. Parankiewicz studied the behaviours of small particles of different substances when suspended in different gases at various pressures and subjected to intense radiation. It was found that Na, K, Cu, Ag, Au, Mg, Zn, Cd, and Hg are *light positive* or move with the light, while Tl, Sn, Pb, P, Bi, S, and I are *light negative*, i.e. move against the radiation. Sb, Se, and Te, when volatilised, may each produce two kinds of particles showing the opposite behaviours. The theory of these phenomena are discussed in the present paper. [See Abs. 425 (1919).] E. H. B.

2084. *Applications of the Quantum Theory to Spectral Series.* **S. Dushman.** (Optical Soc. America, J. 6. pp. 235–250, May, 1922. Paper read at joint session of the Am. Phys. Soc. and the Am. Assoc. for Adv. of Science.)—This paper reviews, and to a certain extent summarises, various recent applications of the quantum theory by Bohr, Sommerfeld, Rubinowicz, and others, to the laws of spectral series. The points dealt with include the fine structure of spectral lines, the Zeeman and Stark effects, the "selection principle," and the "principle of correspondence," with applications of the two latter. A. W.

2085. *Vacuum Hot-Spark Spectrum of Zinc in the Extreme Ultra-Violet Region.* **R. A. Sawyer.** (Astrophys. J. 52. pp. 286–300, Dec., 1920.)

2086. *L-Series of Lutecium and Ytterbium. Identification of Celtium with the Element of Atomic Number 72.* **A. Dauvillier.** (Comptes

Rendus, 174. pp. 1347–1349, May 22, 1922.)—The author has improved his experimental arrangements and has thus been able to study in detail the L-series of lutecium and of ytterbium. Friman and Hjalmar have already found a dozen lines in the group of rare earths. The author has identified 26 lines for lutecium and about half as many for ytterbium. A table is given of the wave-lengths and intensities of these lines measured with reference to the measurements of Siegbahn for the K-lines of copper. *Thulium and Celtium.*—Besides the lines of Lu and Yb faint lines showed the existence in the mixture used of a trace of thulium, for which element high-frequency lines have hitherto not been found. Further, two very faint lines at $\beta_2 = 1319 \cdot 4$ and $\alpha_1 = 1561 \cdot 8$ showed the existence of a trace of celtium and enable the atomic number 72 to be assigned to that element. [See Abs. 1679, 1771, 1995, etc. (1921).] A. W.

2087. *Atomic Numbers of Neo-Ytterbium, Lutecium, and Celtium.* **G. Urbain.** (Comptes Rendus, 174. pp. 1349–1351, May 22, 1922.)—Dauvillier's observations made with the author's rare earth preparations [see preceding Abstract] fix the atomic number of celtium as 72, so that its atomic weight is between that of lutecium (175) and tantalum (181·5). The series thulium, neo-ytterbium, lutecium, celtium thus correspond to atomic numbers 69, 70, 71, 72 respectively. A brief review is given of the history of the three latter elements. A. W.

2088. *The High-Frequency Spectrum of Barium.* **A. Dauvillier.** (Comptes Rendus, 174. pp. 1543–1546, June 12, 1922.)—A continuation of previous work [see Abs. 2086 (1922)]. A study has been made of the high-frequency spectrum of barium, which is, between silver and the rare earths, the element the least fusible and the most easily isolated in the pure state. A small quantity of the pure metal was deposited in vacuo on an antikathode of copper, giving a conducting alloy not easily fused. The absorption of mercury vapour was prevented by condensation. The spectra obtained with this alloy have given important new results. The plates show two white lines L_1 and L_2, whose position coincides with that of the limits of absorption. These lines are followed, on the side of longer wave-lengths, by two faint black lines. The width of the white and black lines is the same, about 0·2 mm., and the distance apart of their centres is about 0·5 mm. The black lines appear to be the homologues of the lines of l' or β'_5 (1036·0) and γ'_2 (899·0), and correspond to the combinations PL_1 and PL_2. They are probably excited in the layer of vapour issuing from the focus. Up to the present all the heavy elements have been found to possess a doublet $\gamma_8\gamma_7$ formed by two strong lines of equal intensity, and presenting a constant wave-length difference. But for antimony γ_8 is much more intense than γ_7. For barium, whose lines are much less diffuse, the same effect has been observed. Moreover, the two lines, which are displaced, both possess a satellite of greater wave-length. Two faint lines were also found at 2211·2 and 2371·7, forming a Sommerfeld doublet. These may belong to the lines O_5L_2 and O_5L_1, of which the second only (β_7) was known for the heavy elements. Besides the above a number of faint lines have been found as satellites of the principal lines such as γ_4, γ_1, β_2. A table is given of the wave-lengths and characters of all the lines (35) observed. A. W.

2089. *Band Spectra of Mercury.* **H. Nagaoka.** (Phys. Math. Soc. Japan, Proc. 4. pp. 61–66, April–May, 1922.)—The present paper gives a résumé of preliminary experiments carried out on the bands given by mercury vapour. A special mercury lamp has been designed and constructed, and this is similar in type to the Paschen lamp. A diagram shows the construction. The lamp is water cooled and is constructed of iron, the arc taking place between the mercury in a tube of fused quartz sealed by cement through the base of the cylindrical chamber, and the mercury in the bottom of the chamber outside the quartz tube. A crucible of fused quartz, provided with a small hole on the lateral face near the rim, was inverted over the end of the tube, the arc taking place inside this. The crucible was held in position by a diaphragm of thin sheet iron, and a second diaphragm was fitted loosely higher in the chamber. The purpose of this arrangement was to keep mercury vapour from obscuring the under face of the quartz prism sealed on the lid of the chamber and serving to reflect the light from the arc through a quartz lens and so to the analysing apparatus. In the earlier experiments a Fuess spectrograph fitted with a Cornu prism was used, and rough measurements were made of the wavelengths of the heads of the bands between λ4517 and λ2470, 29 bands being observed in this region. Preliminary observations were also made with a quartz Lummer plate with the object of obtaining information on the structure of the bands. Rough measurements made with a Hilger constant-deviation spectrometer and a Fabry-Perot etalon showed that three groups of lines are interlaced near λ4359. The bands in this region are in triplets. Further experiments will be made later with a 15-cm. grating now in process of mounting. A. W.

2090. *Absorption Bands of Mercury Vapour.* **J. Franck and W. Grotrian.** (Zeits. techn. Physik, 3. 6. pp. 194–197, 1922.)—A discussion of previous work on mercury vapour by various experimenters leads to the conclusion that in mercury vapour there exists a small percentage of molecules, whose presence is shown by absorption. If this view is correct, it should be possible, by superheating the mercury vapour at constant density, to increase appreciably the degree of dissociation, and thereby weaken or cause to disappear entirely the molecular absorption bands. Further, by measuring the intensity of the absorption bands for different pressures and temperatures, it should be possible to obtain at any rate an approximation to the heat of dissociation of the Hg_2 molecule. Experiments were carried out to test these points. Photometer curves of the λ2540 band at 200° C., 620° C., and at about 1000° C. show a progressive diminution in the intensity with increase of temperature, the band having practically disappeared at the highest temperature. A similar effect was obtained with a higher saturation pressure of mercury vapour in the absorption chamber. In this case the band was still observable, though very faint, at a temperature of 1160° C. The photometer curves show a variation in the intensity of the band in the ratio of about 1 : 5 between the temperatures 235° C. and 1200° C. Calculation from this gives a value for the work of dissociation of about 1 Kil.-Cal. A. W.

2091. *X-Ray Spectra.* **W. Duane and R. A. Patterson.** (Nat. Acad. Sci., Proc. 8. pp. 85–90, May, 1922.)—In previous papers [see Abs. No. 252 (1921)] the authors have given the critical absorption wavelengths of the L-series of 9 of the heavy elements. The bearing of these results on theoretical matters and their relation to other available measurements of X-ray spectra were discussed. In view of more recent work by Smekal, Coster, de Broglie, Dauvillier, and others, the authors have considered it desirable to make a more accurate determination of the L-absorption limits.

Measurements have also been made of the emission and absorption spectra of the K-series of molybdenum, using a calcite crystal of grating space 2nd = 6·056 (10)$^{-8}$cm. (assumed). The following table contains the results of these measurements:

K-SERIES OF MOLYBDENUM.

Line.	Number of Measurements made.	Glancing Angle.	Wave-length × 10^8 cm.	Order.
α_2	3	13° 36′ 08″	0·71213 ± 8	2nd
α_1	3	13° 31′ 07″	0·70783 ± 7	2nd
β'	3	12° 02′ 50″	0·6320 ± 2	2nd
β	6	12° 01′ 50″	0·63114 ± 7	2nd
$\beta\beta'$	1	5° 59′ 05″	0·6314 ± 3	1st
γ	3	11° 48′ 32″	0·6197 ± 2	2nd
γ	1	5° 52′ 30″	0·6199 ± 3	1st
κ	1	5° 51′ 40″	0·6184 ± 2	1st

As the wave-lengths were determined by the ionisation method the authors were able to determine an accurate value of the ratio of the intensities of the α_1 and α_2 lines. From three determinations in the second order the ratio was found to be 1·97 as compared with 2·00 predicted by Bohr. The ratio of the intensities of β to γ in the first order is 6·3 and in the second order is 5·46. A. B. W.

2092. *High-Frequency Spectra: K-series of Platinum.* **J. S. Rogers.** (Roy. Soc. Victoria, Proc. 34. 2. pp. 196-206, 1922.)—A description is given of an accurate method of measuring the wave-lengths of the X-ray spectrum of platinum. The following mean values are given.

Ptα_2 0·1895 ± 2 Å. Units.
Ptα_1 0·1851 ± 1 „
Ptβ 0·1644 ± 2 „
Ptγ 0·1596 ± 2 „
Wγ 0·1794 ± 2 „

A. B. W.

2093. *New Absorption Phenomena with X-Rays.* **M. de Broglie** and **A. Dauvillier.** (Comptes Rendus, 174. pp. 1546-1548, June 12, 1922.)—The authors have already referred in a previous paper [see Abs. 1569 (1921)] to the existence of rays of absorption in the neighbourhood of the upper limit of frequency of X-rays. The effect is of feeble intensity when compared with the ordinary discontinuities of absorption and is only rendered observable by the use of special methods. A. B. W.

2094. *Diffraction of X-Rays in Liquids.* **W. H. Keesom** and **J. de Smedt.** (K. Akad. Amsterdam, Proc. 25. 3 and 4. pp. 118-124, 1922.)—Using the Debye and Scherrer method the authors have examined the structure of liquid oxygen, liquid argon, benzene, water, ethyl alcohol, ethyl ether, formic acid, CS_2, and bromine by means of X-rays. Of these, CS_2 and bromine gave no distinct diffraction figure. The other liquids gave first an intense almost circular diffraction ring. Argon was exposed twice, once in an aluminium tube and once in a glass tube. Of these only the first one gave a distinct diffraction figure. The results are included in the following table, where ϕ is the semi-angle at the apex of the cone formed by the diffracted X-rays:

Substance.	ϕ.	a.
Oxygen	27°	4·0 Å.U.
Argon	27	4·0
Benzine	18	$6{\cdot}0_5$
Water	29	$3{\cdot}7_5$
Ethyl alcohol......	22	4·9
Ethyl ether	19	5·7
Formic acid	24	4·5

It is shown that the intense diffraction ring is due to the co-operation of neighbouring molecules. A second weak ring was found for oxygen and argon—this being ascribed to pairs of molecules which touch each other. A. B. W.

2095. *Increased Accuracy in Measurement of X-Ray Spectra.* II. **M. Siegbahn** and **V. Dolejšek.** (Zeits. f. Physik, 10. 3. pp. 159–168, 1922.)—The paper contains numerous tables of accurate wave-length measurements of the K_α and K_β lines of the elements phosphorus to zinc. A short abstract is not possible. A. B. W.

2096. *X-Ray "Faser" Diagram.* **M. Polanyi** and **K. Weissenberg.** (Zeits. f. Physik, 10. 1. pp. 44–53, 1922.)—A continuation of previous papers on the same subject. [See Abs. 1141 (1922) and Abs. 1622 (1922).] A. B. W.

2097. *Ratio of Ionisation and Absorbed Energy in Ionisation Measurements with X-Rays.* **B. Boos.** (Zeits. f. Physik, 10. 1. pp. 1–21, 1922.)—The author has determined experimentally the variation of the ratio of absorbed energy to ionisation for different wave-lengths of X-rays. A copper-bolometer was used to measure the total energy of the X-ray beam. The measurements indicate that for equal quantities of energy absorbed, hard X-rays have relative to soft rays a much greater heating than ionising power. A. B. W.

RADIO-ACTIVITY.

2098. *Adsorption of Radio-active Substances.* **E. Ebler** and **A. J. van Rhijn.** (Ber. deutsch. Chem. Ges. 54. B. pp. 2896–2912, Nov. 12, 1921.)—Ebler and M. Fellner (*ibid.*, 44. pp. 2332–2338, 1921, and Zeits. anorg. Chem. 73. pp. 1–30, 1911), by shaking radio-active solutions with metasilicic acid gel, had shown that the processes of the chemical analyses and of the preparation of radio-active elements are much complicated by adsorption, and that the influence of the colloids is due to their large surface, but is not directive; the directive influence depends upon the chemical nature. The silica binds the substance because it is acid; and since the gels are ill-defined products, the data of different observers differ, and are frequently not reproducible. This view seems to be inapplicable to the adsorptive power of charcoal. Charcoal is, however, never pure; the purest charcoal (prepared by carbonising pure sugar) has a much smaller selective adsorption for uranium than blood or animal charcoal. The so-called precipitation of radium by $BaSO_4$ is not really a precipitation, and is not complete until all the barium is precipitated; the mere excess of barium (Parsons and others) does not suffice. H. B.

2099. *Radio-activity of Mineral Springs.* II. **E. Ebler** and **A. J. van Rhijn.** (Zeits. anorg. Chem. 119. pp. 135–144, Nov. 3, 1921.)—In 1911 E. E. found $0{\cdot}95 \times 10^{-10}$ Curie of radium per litre of Bad Dürkheim water, but $146{\cdot}7 \times 10^{-10}$ Curie of radium emanation per litre of spring gas. These figures were probably too high, as improved methods later indicated. In 1913 the town of Heidelberg bored several wells for thermal waters. The emanation was found constant down to 600 m. at about 10^{-10} Curie, being higher in the granite of the Löwenbrunnen springs and lower in the Felsenmeer springs in the New Red Sandstone, as is usual in granite and sandstone. The radium salt content was 10^{-12} gm. per litre, and increased with depth to $0{\cdot}97 \times 10^{-10}$ gm. at 590 m.; this observation was novel. The observations show that both the emanation and the radium salt percentage should be determined as they may vary independently of one another, especially in comparing different springs. The measurements were made before the war; the work is now continued by Lenard. H. B.

2100. *Alpha-Particles as Detonators.* **G. H. Henderson.** (Nature, 109. p. 749, June 10, 1922.)—Reference is made to an interesting phenomenon in which nitrogen iodide is detonated on bombardment with α-particles from radium active deposit. With a button of nitrogen-iodide $0{\cdot}1$ cm.^{2} area, a source of RaC (equivalent in γ-activity to about 3 mg. of radium), placed 1 cm. away causes the button to explode in about 20 seconds, i.e. when between 10^7 and 10^8 α-particles have struck it. The time factor is very noticeable, the effect depending on probability conditions. A. B. W.

2101. *Significance of β-Ray Spectra of Radio-active Substances.* **C. D. Ellis.** (Zeits. f. Physik, 10. 5. pp. 303–307, 1922.)—Note referring to a theory of L. Meitner [see Abs. 1639 (1922)] relating to β-ray spectra. A. B. W.

2102. *Interpretation of β-Ray and γ-Ray Spectra.* **C. D. Ellis.** (Cambridge Phil. Soc., Proc. 21. pp. 121–128, May, 1922.)—The paper commences with an account of the general view of β-ray disintegration as evolved from the researches of Rutherford and others. On the author's theory it has been found possible to account for the details of five different β-ray spectra (RaB, RaC, RaD, ThB, and ThD) and so it would appear strong evidence as to the essential correctness of the author's views. Direct evidence is given in contradiction to a theory of β-ray spectra recently put forward by L. Meitner [see Abs. 1639 (1922)]. A. B. W.

HEAT.

2103. *Specific Heat Determinations of Solids by an Adiabatic Electrical Method.* **E. Cohen and A. L. T. Moesveld.** (Zeits. phys. Chem. 100. pp. 151–158, 1922.)—For the determination of the specific heat of solid bodies a calorimeter is applied which was formerly developed for measurements with liquids. The principle consists in mixing a known weight of the solid with a definite weight of an inert liquid of known specific heat. The mixture is placed in the inner cylindrical vessel of the calorimeter consisting of a gold-plated copper vessel of known water equivalent and surrounded with an intervening air space by a water-filled vessel well insulated on the outside. An electrical heater, which, by rotating also acts as a stirrer, is immersed in the inner mixture and is composed of a rectangular plate wound with constantan wire and coated with a layer of caoutchouc which is vulcanised, coated with graphite, and finally gold-plated. The inert liquid in the central vessel is selected to be of approximately the same density as the solid, so that the latter remains completely in suspension during the stirring. The measurement consists in determining the amount of current required to be passed through the electrical heater in order to raise the temperature a given amount as measured by a thermometer. The value obtained is compared with that given by a liquid of known specific heat under similar conditions. Measurements are made in this way of the specific heat of $CdSO_4 . 8/3H_2O$ when suspended in bromoform. **J. N. P.**

2104. *The Heats of Vaporisation and the Differences m′ − m of the Specific Heats in the Saturation State for Argon, Oxygen, Nitrogen, and Hydrogen.* **E. Mathias, C. A. Crommelin, and H. K. Onnes.** (Comptes Rendus, 174. pp. 1395–1397, May 29, 1922.)—In a previous note [see Abs. 1110 (1921)] the possibility was shown of calculating the heats of vaporisation L and the differences $m' - m$ of the specific heats of saturated vapour and liquid at T° for argon, oxygen, nitrogen, and hydrogen, by means of density measurements and various vapour tension data. The heats of vaporisation are given by the Clapeyron-Clausius formula, $L = T/J(\frac{1}{\delta'} - \frac{1}{\delta})dp/dT$, and the specific heat differences by the formula $m' - m = dL/dT - L/T$, the letters denoting the usual physical quantities. The present communication now supplies numerical data for these gases based on the above method, the data sources being given. **H. H. Ho.**

2105. *Temperature Correction in Bomb Calorimetry.* **N. H. Engström.** (Tekn. Tidskr. Kemi Berg. 51. pp. 18–21, 1921. Chemical Abstracts.)—The author gives a simple formula replacing the equations of Regnault-Pfundler. This formula; $K = (1 - n)\,v_1 - v_n$ was tested by many determinations, and found rarely to be in error by as much as ± 0·003°. **H. B.**

2106. *Deviations of Carbon Disulphide from the Gas Laws.* **A. Schulze.** (Zeits. anorg. Chem. 118. pp. 223–230, Sept. 5, 1921.)—Carbon disulphide vapours, like vapours of certain hydrocarbons and water, show association of the molecules. When the CS_2 vapour is mixed with ethyl-ether vapour, the CS_2 is in the mixtures associated to 0·14 per cent. at 80° and 1 atmo., whilst pure CS_2 shows an association of 2 %

under the same conditions in vapour-pressure determinations; the latter figure agrees with Bartelli. When the gas pressure is raised from 1 atmo. to 2 atmo. the association is increased by 0·5 %. At constant pressure the association decreases as the temperature rises (79° to 130° C.), whilst it increases with the pressure at constant temperature. There must already be association of CS_2 in the liquid phase. H. B.

2107. *Vapour Pressure of Sulphur Dioxide and Ammonia.* **F. W. Bergstrom.** (J. Phys. Chem. 26. pp. 358–376, April, 1922.)—By means of an improved apparatus for the measurement of vapour pressures below 900 mm. at low temperatures, the vapour pressures of ammonia and sulphur dioxide have been determined at temperatures ranging from above the boiling-points to the freezing-points. Unlike the results of Burrell and Robertson [Abs. 1154 (1917)], which are shown to be probably erroneous, and those of Brill [Abs. 85 (1907)], those now obtained are in agreement with Ramsay and Young's relationship, namely, $R' = R + c(T' - T)$, where R′ is the ratio of the absolute temperature of any liquid to that of a standard substance at a given vapour pressure, R the value of the same ratio at another vapour pressure, T′ − T the difference between the absolute temperatures of one of the liquids at the two vapour pressures, and C a constant for every pair of substances. The triple point of ammonia is found to be at −77·9° at a pressure of 45·5 mm. T. H. P.

2108. *A New Evaluation of the Internal Pressure of Liquids. A Criterion of Molecular Association in a Liquid.* **N. V. Karpen.** (Comptes Rendus, 174. pp. 1693–1695, June 26, 1922.)—This paper contains a new method for the evaluation of the internal pressure discovered by Laplace and designated as K. When a liquid is expanded, the pressure p performs the external available work, and the pressure K the internal work, so that if p, v, T represent the initial condition and an isothermal expansion be caused so as to produce a volume increase dv and a reception of heat $d\phi$ by the liquid, then $(p + K)dv = Jd\phi = Jl dv$, where l is the latent heat of expansion at constant temperature, and the molecules are assumed to remain the same, i.e. their masses and individual energies are unaltered. Replacing l by its value from Clapeyron's formula, there follows $K = T\,(dp/dT)_v - p$. When $(dp/dT)_v$ is not known, it may be replaced by α/μ, where α is the coefficient of expansion and μ the coefficient of compression, giving $K = T\,\alpha/\mu - p$. A table of results is given for ether, ethyl alcohol, water, ethyl chloride, methyl alcohol, isopentane, and mercury at 192° C. For normal conditions the ratio K/P_c, where P_c is the critical pressure, is shown to be constant and departures from it afford a criterion of molecular association in liquids. When the latter occurs, it is necessary to introduce the heat dq absorbed by the molecular dissociation into the formula, which then becomes, $J dq/dv = T\alpha/\mu - K - p$. Molecules will be associated if dq/dv is not zero. Below 200° C. water molecules are found to be associated, and their dissociation is accompanied by evolution of heat, explicable by the transformation of the speed of rotation or oscillation of associated molecules into speed of translation of the dissociated molecules therefrom. H. H. Ho.

2109. *The Velocity Distribution Function and the Stresses in a Non-Uniform Rarefied Monatomic Gas.* **J. E. Jones.** (Roy. Soc., Phil. Trans. 223. pp. 1–33, June 26, 1922.)—The determination of the distribution of the molecular velocities in the non-uniform state of a gas is in general necessary in applying the kinetic theory to the investigation of its physical properties. Boltzmann showed that the function which expresses the law of distribution of the molecular velocities must satisfy a certain integral equation, and Enskog, in 1911, applied to this equation the method of solution by series, and thus obtained the form of the function. He later succeeded in obtaining numerical values of the coefficients of viscosity, heat conduction, and diffusion. The same results were obtained also by Chapman by applying Maxwell's "equation of transfer" to certain odd and even functions of the molecular velocity. Chapman and Enskog applied their methods chiefly to the case of a gas in which the mean free path of a molecule is small compared with the scale of length in which the properties of a gas vary appreciably. In the present paper the solution is extended to gases in which this condition no longer holds. A new "equation of transfer," which is different in form from that of Maxwell, forms the basis of the method, and provides a simpler and more direct means of calculating the rate of change of molecular properties by collision than has been used hitherto. This equation, together with Boltzmann's equation, readily provides a solution of the distribution function to any desired degree of completeness. It was shown by Maxwell that stresses are set up in a gas by non-uniformity of temperature; in a normal gas these stresses are negligible, but in a rarefied gas this is not so, and provides a possible explanation of the phenomena of the radiometer. The investigation is here dealt with afresh by the special methods of this paper, and general formulæ obtained for the stresses. The various special molecular models discussed include centres of force varying inversely as the nth power of the distance and rigid elastic spherical molecules. In the former case Maxwell's result for $n = 5$ is confirmed, and in the latter the calculations are carried to the third approximation, and the numerical coefficient obtained differs by 20 % from that of the Maxwellian gas. A detailed comparison of the results with those of previous writers is given in the concluding paragraph. T. B.

2110. *Restricted Movements of Molecules at very Low Pressures: a Limit of Applicability of the Second Law of Thermodynamics.* **A. Fairbourne.** (Phil Mag. 43. pp. 1047–1056, June, 1922. Nature, 110. pp. 113–114, July 22, 1922.)—It has often been stated (cf. Maxwell, 1871, "Theory of Heat," p. 308) that if sufficiently minute apparatus could be constructed to restrict the movements of certain individual gaseous molecules so as to direct, for example, those with high velocities into one portion of the system and those with low velocities into another, a continuous creation of potential would result which would render the k.e. of the molecules continuously available for the performance of external work. It is shown by simple geometrical reasoning that it is not impossible to construct an apparatus capable of selectively affecting molecules travelling in certain desired *directions*, provided that the dimensions of the apparatus are smaller than the free paths of the molecules employed. For example, let ABCD be a two-dimensional vessel, the shape of which corresponds to the cross-sectional elevation of a truncated right-angled cone. Let it be open at the top, AD, and bottom, BC, and let BC be twice AD. It is easy to show that while N molecules pass from AD to BC, less than N pass from BC to AD: that is, *a downward flow has been created*. This flow will produce a pressure potential on surfaces exposed to it, and external work can consequently be obtained at the expense of the k.e. of the gas enclosed in the system. A vane mounted with sufficiently minute friction inside or below one of the vessels described, the vessel itself being suspended in a gas at suitably low pressure, should therefore be capable of realising experimentally the theoretical conceptions of Maxwell, and should yield mechanical work at the expense of the k.e. of the molecules, a result which could not be obtained in any experiment coming within the application of the second law of thermodynamics. **R. d'E. Atkinson.** (Nature, 110. pp. 112–113, July 22, 1922.) Letter on the above. T. B.

2111. *On the Entropy Change during the Expansion of Compressed Gases in the Absence of Work.* **V. Njegovan.** (Zeits. Elektrochem. 28. pp. 259–263, June 1, 1922.)—The conditions for the validity of the entropy equation of the perfect gas, $S = C_v \log T + R \log V + \text{const.}$, are first discussed, this being a case where entropy increases during typical irreversible processes. The problem is next considered of entropy change during the expansion of a compressed gas into vacuo. Here the ideal equations have no validity; specific heats of real gases are not constant, but depend on both temperature and pressure, while cooling or heating ensues on expansion into vacuo according as the compressed gas is below or above the so-called inversion-point [Joule-Thomson effect]. The author treats the problem for two cases, where experimental data are available, viz. 1). Carbon-dioxide at 70–50 atmos., and initial temperature of 67·6° C. Here the measurements of Lussana and Amagat indicate an increase in the specific heat at constant volume with falling temperature, which is opposed to the decrease involved by the expansion itself. Between the limits considered the entropy is found to decrease appreciably. The Joule-Thomson effect is very thoroughly examined. (2) Water-vapour at 4000° C. from 17–7 atmos. This is investigated by means of the experimental data of Schule. Here the entropy is found to decrease, but in the neighbourhood of 7 atmos., where the gas begins to approximate to the ideal state, a small increase is detected. The results indicate that so-called irreversible processes merit further consideration. H. H. Ho.

2112. *Revision of the Entropies of the Elements.* **G. N. Lewis, G. E. Gibson, and W. M. Latimer.** (Am. Chem. Soc., J. 44. pp. 1008–1017, May, 1922.)—New data and new methods have become available which warrant a revision of the table of entropies of the elements given by Lewis and Gibson [Abs. 177 (1918)]. Starting from the equation $S = 1{\cdot}5\,R\,\text{en}\,T + R\,\text{en}\,V + 1{\cdot}5\,R\,\text{en}\,W + C$, where W is the molecular weight of the gas, it is shown that, at 25° and 1 atmosphere, the equation $S = 1{\cdot}5\,R\,\text{en}\,W + 25{\cdot}70$ holds. Sufficiently accurate experimental determinations of the entropy to justify comparison with the values resulting from this equation have been made only for the monatomic gases, He, Ar, Cd, and Hg, for which the experimental (and calculated) values are respectively: 29·2 (29·8), 36·4 (36·7), 40·0 (39·8), and 41·3 (41·5). The entropies of a number of other elements have also been calculated from the above equation, and a table is given of all the atomic entropies which have been as yet calculated. T. H. P.

2113. *On the Principles of the Theory of Quanta.* **P. S. Epstein.** (K. Akad. Amsterdam, Proc. 24. 8. pp. 1193–1205, 1922.)—The quantum theory in the form which Planck gave it in 1911 depends on the application of statistical mechanics in the so-called phase-space of the canonical position- and impulse-coordinates $q_1q_2 \ldots q_f, p_1p_2 \ldots p_f$, and consists in dividing this space into elementary regions of probability. The method obtains a considerable simplification for the soluble mechanical systems, since for them each impulse-coordinate $p_i = p_i(q_i)$. Instead of the $2f$-dimensional phase-space (f being the number of degrees of freedom of the system) it is then sufficient to consider the f phase-planes (p_i, q_i), which, as the author has shown previously [Abs. 49 (1917)], gives great advantages in the treatment of these systems. In each of these planes the successive conditions of the system are represented by a curve which for the class of conditioned-periodic motions are as a rule closed, this class having had its quantum conditions established. Planck's hypothesis, as extended by Sommerfeld and the author, consists in the assumption of the existence among the states of the system of certain preferential or stationary motions which are represented by discrete curves in the diagram, the area of the phase-plane between 2 successive stationary curves being equal to the universal constant h. If the arc a of the narrowest of these curves is equal to h_0, that of the $(n + 1)$th stationary orbit is $\int pdq = h_0 + nh$; the determination of h_0, therefore, will fix all stationary curves. For this purpose Planck assumes that the narrowest orbit must coincide with the natural boundary of the phase-plane; i.e. on any grounds connected with the nature of the system, the above integral, which is essentially positive, cannot fall below a definite value, the latter has to be taken as h_0. In most cases a lower limit of that kind does not exist, so that $\int pdq = nh$. In his treatment of the relativistic Kepler-motion, Sommerfeld found the case to be different; and gave a lower limit $p_0 = \mathrm{K}e^2/c$ for the constant azimuthal impulse, which gives $h_0 = 2\pi p_0$, where e is the charge of an electron, Ke that of the atomic nucleus, and c the velocity of light. Planck pointed out that it would be necessary to take the first integral as the fundamental relation, whereas experiment (the Balmer series) can only be reconciled with the second. Sommerfeld tried to remove this contradiction by pointing out, that when the motion of the nucleus is taken into account the numerical value of the limiting impulse is smaller than $\mathrm{K}e^2/c$. The present author now hopes to prove that the limitation of the phase-plane by the value $p = p_0$, is only an apparent one, even if the motion of the nucleus is left out of account, and that p can very well fall below this value; at the same time the character of the motion is essentially changed. The admissibility of stationary orbits of azimuthal impulse $p = 0$, which on Sommerfeld's theory seemed to be excluded is thereby proved in principle. As long as attractive forces (nucleus and electron) are dealt with, these orbits are hardly of practical importance, as they must lead to a collision of electron and nucleus. But the case changes when the forces are repulsive (nucleus and α-particle), the orbits being then hyperbolic. If the quantisation of such orbits is admitted, interesting physical conclusions follow which appear to give an explanation of some recent experimental results by Rutherford. The quantisation of non-periodic motions is therefore defunct in the present paper. Section 2 examines the apparent boundary of the phase-plane $p = p_0$. Section 3 discusses the quantisation of the spiral orbits, which reduces to that of the radial impulse and its dependence on the radius vector and certain constants. Section 4 deals with the more important physical problem of the quantisation of the hyperbolic curves. Section 5 investigates the collision between an α-particle and an atomic nucleus in detail, taking into account the motion of the nucleus, but neglecting the unimportant relativistic correction. Section 6 describes the recoil-rays of hydrogen, and Section 7 the transition to stationary orbits. It is found that in addition to particles which have completed the transition into the stationary orbit, others are to be expected, even with the highest velocities, which, owing to a higher initial impulse, have not succeeded in so doing. The directed radiation must therefore be surrounded with a scattered radiation; this appears to be the case in some of Rutherford's experiments, in which the recoil rays are in reality less homogeneous than appeared originally, and, that side by side with the rapid H-particles observed at first, there are others of smaller speed. H. H. Ho.

2114. *The Vibrations of a Mechanical System and its Quantum Relations and the Specific Heats of Solid Bodies at High Temperatures.* **M. Born** and **E. Brody.** (Zeits. f. Physik, 8. 3. pp. 205–207, 1922.)—Certain numerical errors in the formulæ given in these papers [see Abs. 1154 (1922)] have been pointed out by R. Becker. These are now corrected, and lead to slightly different values for the energy U and the specific heat C_v as follows:—$U = 3RT - 9/2\sigma R^2T^2$, *in place of* $3RT - 9\sigma R^2T^2$; $C_v = dU/dT = 3R(1 - 3\sigma RT)$ *instead of* $3R(1 - 6\sigma RT)$, where σ stands for an expression involving quantum numbers, the sign of which will determine the variation in energy and specific heat. T. B.

2115. *Some Fundamental Questions in the Kinetic Theory of Heat.* **S. Boguslawski.** (Phys. Zeits. 23. pp. 209–219, May 15, 1922.)—One of the most important questions which a kinetic theory of heat has to answer is the mechanical meaning of the thermal ideas of temperature, entropy, and thermodynamical potential. This question has up to the present time received no satisfactory answer. The most important result that has been reached at present is Boltzmann's reference of the idea of entropy to that of the probability of a condition of state. Alone, this cannot be considered as a final solution of the problem, since in the first place the idea of probability is not a mechancial one, and, secondly, an evaluation of the probability of a condition of state which is free from objection from *a priori* considerations is only possible in a few of the simplest problems. This is best shown from the fact that Einstein's reversal of Boltzmann's principle to the determination of the probability from the entropy has proved very successful. The author's attempt to refer the thermodynamic principle to that of "smallest working" is essentially a return partly to older and partly to newer, but discarded, ideas of Boltzmann, Clausius, and J. J. Thomson, the ideas being taken up from a new aspect and with reference to new problems. More experimental material was necessary for Boltzmann's theories, and it was the discovery of quantum phenomena which destroyed our belief in the proportionality between mean kinetic energy and temperature, and left us free to conduct investigations on new lines. Some of the author's mathematical conclusions appear to agree well with Bohr's results for the structure of the H atom, and with the investigations of Ehrenfest on the theory of adiabatic invariants. T. B.

SOUND.

2116. *Phonelescope.* **H. G. Dorsey.** (Optical Soc. America, J. 6. pp. 279–280, May, 1922).—The phonelescope has been devised for demonstration and research in sound and electricity, making visible either of these forms of wave motion. A tiny steel shaft is mounted in jewelled bearings in front of a diaphragm, and any motion of the latter causes the shaft to rotate through a proportionate angle. A mirror on the shaft deflects a beam of light so that the motion of a spot of light gives a trace of the motion of the diaphragm magnified from one thousand to twenty thousand times. Suitable adjustments and optical arrangements are provided. With the horn attachment for sound the actual wave-forms may be shown to classes for sounds produced by the voice, forks, pipes, etc. There is also an electromagnet attachment or telephone receiver which may be screwed into the back of the casing and, by the attraction of the diaphragm, this converts the instrument into a polarised direct-current galvanometer, an alternating-current vibration galvanometer, or an oscillograph. It can also show the combination of a sound (say, 660 per second) with electric oscillations (say, 60 per second) as reproduced in the paper. E. H. B.

2117. *A New Pipe.* **W. Burstyn.** (Zeits. techn. Physik, 3. 5. pp. 179–180, 1922.)—For flexible high-pressure conductors seamless metal pipes have for some years been in use, the flexibility being produced by the impression of a somewhat deep spiral groove. A spiral tube of this kind had an outside diameter of 13 mm. and a wall thickness of 0·2 mm. By blowing (or sucking) on such a pipe 30 cm. long, it was found to give a fairly pure pipe tone, whose place in the series of partials depended upon the pressure of the blast. E. H. B.

2118. *Physical Examination of Hearing and Aids for the Deaf.* **R. L. Wegel.** (Nat. Acad. Sci., Proc. 8. pp. 155–160, July, 1922.)—The function of the auditory sense is to detect sounds of various kinds and wave-shapes varying over or through pressures on the ear drum of from about one-thousandth of a dyne per sq. cm. to one thousand dynes per sq. cm., and over a considerable part of this range to differentiate with certainty between complex sounds so nearly alike that no existing physical apparatus can separate them. The abnormal auditory sense may be regarded as lacking more or less in (*a*) range of sensation both in frequency and intensity, (*b*) quality of sensation in various regions of the range, (*c*) the binaural sense. Apparatus and methods have been developed by means of which the outstanding elements of these functions can be measured and to a limited extent compensated for. A logarithmic graph is given coordinating r.m.s. pressures in dynes per sq. cm. with frequencies for 72 normal ears over a range of 60 to 4000 per second. The limits of maximum and minimum audibility are shown on this diagram, also the regions within of most use and of less use in speech. Many ears which are practically normal are found to have small abnormal areas, as indicated on the above-mentioned diagram. [See Abs. 1164 (1922).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

2119. *Thermic Analogue of the Oersted-Ampere Effect.* **O. M. Corbino.** (Accad. Lincei, Atti, 30. i. pp. 301–305, May 8, 1921.)—In a previous paper [Abs. 936 (1921)] it was shown that if the transport of heat and of electric current be both due to the movement of negative electrons only, a radial thermic flux normal to a magnetic field should give rise to a Barlow wheel effect. Drude's theory of the opposed travel of ions of opposite sign leads to a zero mechanical effect. On trial it was found that if there were any mechanical effect it was not as much as one-20,000th part of that which would appear on the negative-electron theory. At the same time, this is not conclusive in favour of Drude's theory; for it is found (to be explained in a later paper) that the Lorentz-Ganz theory also brings in a flux of thermal energy without temperature-differences in a sense opposed to the electronic flux, and that this brings the aggregate mechanical effect down to zero. A. D.

2120. *Units of Field Intensity and Magnetic Induction.* **H. Abraham, E. Brylinski, D. Berthelot.** (Soc. Franç. Elect., Bull. 2. pp. 201–217, April, 1922.)—The paper is a continuation of earlier discussions [Abs. 1350 (1922)]. Abraham objected to the proposal of the Electrotechnical Committee to express the values of magnetic inductions and magnetic fields, respectively, in terms of units of different name. They are both, by definition, quantities of the same kind. He knew of no experimental fact indicating any distinction between them as now defined. Brylinski urged that it was unjustifiable to assume the magnetic permeability, μ to be, in all cases, a pure number, and proposed that the question should be submitted to the International Electrotechnical Committee. Berthelot agreed with Brylinski. He stated further that Pellat, in 1909, had referred to confusion introduced by defining B, the vector magnetic induction: (1) according to Maxwell, as the sum of the field vector H and 4π times the magnetisation vector I; (2) by the condition that the product $\epsilon\mu$, where ϵ is the dielectric specific inductive capacity, should, in any system of units, represent the square of the speed of propagation of an electromagnetic wave, and B should be such that the energy dw in a volume dv of the electromagnetic field should satisfy the equation $8\pi dw = \mathsf{BH}dv$. Pellat preferred (1), while Brylinski had recently pointed out that Potier had, ten years earlier, expressed himself in favour of (2). The question now was, therefore, the question of twenty years ago, and Berthelot asserted that Potier's opinion is being accepted by a steadily increasing proportion of designers of electrical machinery. G. W. DE T.

2121. *Experimental Test of the Applicability of the Quantum Theory to the Magnetic Field.* **W. Gerlach** and **O. Stern.** (Zeits. f. Physik, 9. 6. pp. 349–352, 1922.)—In a previous paper [Abs. 1009 (1922)] the theory of an experiment to test the applicability of the quantum theory to the magnetic field was given. The experiment has now been carried out, a positive result being obtained. Photographs are reproduced showing the effects obtained with and without a magnetic field acting on a stream of silver particles. A. W.

2122. *Electrodynamics of Homogeneous Media and Isotropes.* **L. Roy.** (Comptes Rendus, 174. pp. 1229–1232, May 8, 1922.)—Referring to a suggestion of P. Duhem that the arbitrary numerical constant (Helmholtz' constant) employed in Helmholtz' electrodynamic theory may be regarded as the product of the specific inductive capacity by the permeability, a mathematical argument is developed to show that this view is untenable. A. B. C. L.

2123. *Dynamical Similarity.* **J. Hadamard.** (J. de Physique et le Radium, 3. pp. 149–153, May, 1922. Paper read before the Soc. franç. de Physique.)—The author shows that the differences of opinion as to the identity of magnetic induction and field intensity expressed in recent discussions of the Soc. franç. de Physique [see Abs. 1950 (1922)] may be attributed to the latter quantity being expressed by a vector representing a direction in space, while the former is expressed by a vector representing a rotation around an infinitesimal area [which Maxwell calls vectors of the first and second class, respectively]. The latter change sign when the axes are reversed in sign, while the former do not, so that no question arises when numerical values are sought, but more exact geometrical specification is necessary in relativistic discussions. The author points out that this need arises in Darboux's treatment of curves in three-dimensional space, the curvature and the torsion being, respectively, the measures of vectors in the directions of the binormal and the tangent, these being the corresponding components of the instantaneous rotation of the mobile trihelion. Now, when the signs of the axes are changed, the tangent retains its sign, while that of the binormal is reversed. This would, however, make the torsion a polar quantity, and the curvature an axial one, the converse of the truth. The discrepancy is due to the instantaneous rotation being itself an axial vector, or vector of the second class, and is the exact analogue of the origin of the difficulty arising in respect of **H** and **B**. The author's solution is to replace the expression of the dimensions of a physical quantity in the form $L^aM^bT^c$ by the more complete one $L^aM^bT^cA^d$. He would call A the unit of axiality, and the exponent *d* would be a quantity of modulus 2, viz., even values of *d* would be taken as 0, and uneven values as 1. G. W. de T.

2124. *Corresponding Compatible Electromagnetic and Gravitational Fields.* **T. de Donder.** (Comptes Rendus, 174. pp. 1228–1229, May 8, 1922.)—Mathematical. A special factor is introduced by means of which an electromagnetic and gravitational field can be prescribed without reference to applied forces. A. B. C. L.

2125. *Tribo-Electricity.* **P. Cardani.** (N. Cimento, 23. pp. 199–214, Feb.–March–April, 1922.)—Describes experiments on the charge produced by rubbing such substances as ebonite, sulphur, sealing wax, paraffin and glass with a surface of woollen cloth. The charge produced was determined by balancing it against the discharge of an electrometer due to a layer of thoria. It was found that the charges produced by a given number of strokes on the above substances were in the ratio of 100 : 100 : 62 : 23 : 13 respectively. The curve connecting charge and length of rubbing became almost horizontal after 100 strokes. The effect of thickness of the substance was also determined. J. W. T. W.

2126. *Tribo-Electricity.* **E. Thomson.** (Am. I.E.E., J. 41. pp. 342-345, May, 1922.)—Frictional electricity is in reality merely contact electricity, the contact being made good by considerable pressure. The running of a leather belt over a pulley is often productive of large charges, which in large pulleys may give sparks of even five feet length. The Volta condensing electroscope is considered exactly analogous to ordinary frictional electrification, for in the latter case the unlike electricities are brought very close to one another and then separated with consequent great rise in potential. P. E. S.

2127. *Franklin's Experiment on the Leyden Jar with Movable Coatings.* **G. L. Addenbrooke.** (Phil. Mag. 43. pp. 489-493, March, 1922.)—The simplest form of the experiment is to charge the Leyden jar and then, by an insulated hook, to lift the inner coating out, touch it against the outer coating, and finally to replace it. It is found that when taken out the inner coat carries scarcely any charge, and that when put back a nearly full discharge can still be obtained from the jar. A similar result follows if both coatings are removed, touched, and replaced. This has been taken to mean that when there are two charged electrodes separated by a dielectric and the electrodes are removed the energy is left stored in the dielectric and remains until the electrodes are replaced and short-circuited, or until dispersed by some indefinite form of leakage. To investigate the matter further the author substituted solid paraffin for the glass dielectric on account of its high insulating properties and because the surface is not so hygroscopic as that of glass. The jar was connected to an electroscope and charged from an electrophorus. On lifting out the inner coating the result is the reverse of that described above; the charge is carried out also, as shown by the electroscope, and on earthing or connecting with the outer coating and then replacing, the jar is found to be discharged. These results are now in accord with the Faraday-Maxwell theory, and with known electrostatic laws; the action on the dielectric is inductive, and if the inner charge is brought outside, the lines of force no longer go through the dielectric, which becomes normal and neutral. The glass experiment is then varied. It is carried out in a cupboard containing thoroughly dried air with dried glass. The effects are then the same as with paraffin. In the ordinary case of the glass jar the condensed moisture on the surface is sufficient to form a semi-conducting film. While the electrode is being removed and its potential is rapidly increasing there is a strong tendency for the charge to flow on to the glass surface and the charge is not carried away with the coating. To arrive at a clear understanding of the action of electric fields on dielectrics the correct interpretation of the experiment is essential. T. H.

2128. *Electrification by a Solid in Liquid.* **U. Doi.** (Phys. Math. Soc. Japan, Proc. 4. pp. 17-21, Feb., 1922.)—The work of Ebert and Hoffmann, on the negative charge on metals when dipped in liquid air, suggests a parallel case, viz., the result of dipping heated metal in liquids, *e.g.*, oils. On the lid of a gold-leaf electroscope is a glass beaker containing the oil; a glass rod coated with paraffin rests on the beaker and supports a heated metal sphere. It is found that if the sphere be partly immersed the oil becomes negative, as shown by the electroscope; but if the sphere be fully immersed, no charge is seen. The ionised + and − charges fully recombine as they are formed in the latter case; whereas the + charge, formed on the sphere in the former case, escapes, leaving the − charge on the oil to show itself. The + charge is found by experiment to escape, not by the vapour rising from the oil as might be supposed, but by the sphere giving up its charge to the air on the upper unimmersed part. In a dark room a light of a yellow-green colour, too faint for photography, perceived at the boundary surface of the oil and hot sphere as vapour is being produced. **P. E. S.**

DISCHARGE AND OSCILLATIONS.

2129. *Brush Discharge.* **F. Trey.** (Phys. Zeits. 23. pp. 193–196, May 1, 1922.)—The author has previously shown how photographs of the brush discharge light tracks can be obtained [Abs. 182 (1922)]. The present paper gives the results, with photographs, of observations of discharges gradually merging into spark discharges. **A. W.**

2130. *Manometric Observations at the Poles of the Electric Arc.* **H. E. G. Beer and A. M. Tyndall.** (Phil. Mag. 42. pp. 956–971, Dec., 1921.)—A further investigation of the hydrostatic pressure observed by Dewar in the arc at carbon electrodes drilled centrally along their lengths. A wind-pressure method is adopted for a straight horizontal arc. The pressure in the holes is observed by a Chattock-Fry tilting bubble gauge, or by a Fry diaphragm. With a silent arc the pressure is positive at the anode, and negligible or slightly negative at the kathode; with a hissing arc the anode pressure is greatly reduced. The effects are variable and difficult to correlate, even when all the readings for which the arc is not centred round the holes are discarded. It is shown from the time variations of the pressure that at first evolution of gas from the carbon is the main cause of pressure, which falls as the supply of gas becomes exhausted. By constricting the holes the pressure could be increased one hundred-fold. A long series of experiments with carbons which had been denuded of gas shows that there is still a residual pressure which might be attributed to an electric wind. In no case, except with new undenuded carbons, are pressures obtained as high as those recorded by Dewar (1 to 2 mm. of water) though the signs of the effects are in agreement. The residual pressure at the anode is practically, if not wholly, independent of the length of the arc, suggesting that it originates in a layer quite close to the anode, and that the Dewar pressure does not arise from wind-producing ions moving in the main body of the arc. The main body of the arc has no net space-charge, and is presumably a region of intense ionisation and recombination; the proportion of the currents carried by the two signs of ions is that of their respective mobilities. The excess hydrostatic pressure is set up at the anode by the motion of an unbalanced space-charge of negative ions in a very thin layer close to the electrode. The results indicate that this pressure is proportional to the current carried by the arc. A long arc enclosed in a quartz tube is also used.

If there is an electric wind in the main body of the arc a large fraction of the momentum should be transmitted laterally to the air in the tube and should lead to an excess pressure at one end. No such pressure is observed. Quantitative work at the kathode is almost impossible, but the effects appear to be roughly similar to those at the anode. When the luminous patch of the arc covers the hole centrally the pressure is positive and may be large, but if the patch is off the centre the pressure is negative. This suggests that as at the anode there is a space-charge at the luminous spot itself. An explanation of the negative pressure is given based on the emission of negative thermions from the hot carbon surrounding the luminous patch.

Forces Acting upon the Poles of the Electric Arc. **A. M. Tyndall.** (*Ibid.*, pp. 972–981.)—Duffield, Burnham, and Davis observed a mechanical pressure on each pole of the arc tending to thrust them apart [Abstracts 709 (1921) and 1643 (1920)]. Duffield, explaining this, rules out all motion of ions which arises from electrostatic forces within the arc, and regards the force on the kathode as due to the recoil from the projection of high-speed electrons, while the force on the anode is due to the transference of the momentum of the electrons, either directly or indirectly, by its communication to the gas as drag. The author criticises this theory. It is shown in the experiments on the Dewar effect that the main body of the arc contributes practically nothing to the electric wind and must contain equal quantities of each sign of ion at all points in the main body. Assuming Duffield's view of high-speed electrons projected from the kathode and passing across the arc without exerting drag on the gas, it is shown that, to satisfy the result quoted above, there must exist a slope of gas pressure across the arc which would have been readily detected in the wind-pressure experiments. The author puts forward a theory of the Duffield effect based on the effects of viscously moving ions. It is shown that if such ions are moving steadily between two large parallel plate electrodes, the pressure differences set up in the gas by the viscous drag of the ions will just balance the electrostatic reaction on the electrodes and the plates will be in equilibrium. This holds only when complete symmetry in all the discharge conditions is present. When the ions are accelerating under the action of the field symmetry is generally lost and the electrodes are no longer in equilibrium. Thus in the act of starting from rest close to one of the electrodes while the ion is accelerating the electrostatic recoil felt by the electrode is in excess of the opposing effect due to the decrease of gas pressure caused by the viscous drag of the ions because the speed of the ions is below that of the steady state. If the ions are projected from the electrode with a high velocity and then slow down near the latter to the steady state the conclusion is the same, the recoil felt by the electrode is in excess of the suction due to the slowing down of the ions. The momentum left in the ions is equal and opposite to that received by the electrode. This is imparted to the electrode at the other end of the path and thus provided the ions reach the velocity of viscous motion close to the electrode from which they start the electrodes will be thrust apart by forces determined by the momentum put into the ions in reaching that velocity. The magnitude of the forces is calculated, using Langevin's expression for the mobility of an ion and Wellisch's value for the mean free path. It is found that results of the right order are obtained if the ions are singly charged molecules. If the ions are electrons their mobilities would have to be far in excess of the values expected from measurements at lower temperatures. In flames and air drawn from the arc the negative ions are electrons, but it is possible that the nearly saturated state of carbon vapour in the arc makes the ion, while in the vapour, more complex than is generally supposed, or the mobility formulæ may break down at the high arc temperature.

T. H.

2131. *Photoelectricity.* **E. Tedeschi.** (N. Cimento, 23. pp. 133–173, Feb.–March–April, 1922.)—A critical résumé of the subject, dealing with the effect of the intensity and wave-length of light on the number of electrons emitted and the velocity of emission, the normal and selective photoelectric effects, theories of the action, including the statistical theory of Richardson. At the conclusion of the paper an extensive bibliography of the subject, as far as the year 1917, is given.

J. W. T. W.

2132. *Pressure Differences in the Positive Column in Argon, Neon, and Helium.* **A. Ruttenauer.** (Zeits. f. Physik, 10. 4. pp. 269–274, 1922.)—The gas pressures at the kathode and anode were measured by two separate McLeod gauges. A pressure difference between anode and kathode of 4×10^{-3} mm. of mercury could be read easily. Four different discharge tubes were employed, and these were supplied with sodium electrodes for arc discharges. Skaupy and Hamburger have previously shown that in argon the pressure difference between the anode and kathode depends on both the gas pressure and the current density. Tabulated results show that with constant current density the pressure difference in argon, neon, and helium is approximately inversely proportional to the gas pressure p in the tube, and $p \cdot \Delta p$ is consequently approximately constant. Other results show that in all three gases at constant gas pressure the pressure difference Δp between kathode and anode is directly proportional to the current density. The results for the three gases show that Δp is approximately proportional also to the square root of the molecular weight, and depends on the length and cross-section of the discharge tube employed.

A. W.

2133. *Stark Effect for the Alkalies.* **R. Becker.** (Zeits. f. Physik, 9. 5. pp. 332–348, 1922.)—A mathematical paper in which, without recourse to the principle of selection, it is shown that an approximate formula for the quadratic Stark effect for the alkali metals may be obtained, if it is assumed that the disturbing effect of the electrons near the nucleus on the path of the light-giving electrons, is to a first approximation given by a term c_1/r^3, where the magnitude of c_1 is found from spectral tables by means of the relative defects of the actual terms from the ideal Balmer series terms.

A. W.

2134. *Passage of Canal Rays through Solid Bodies.* **H. v. Traubenberg and J. Hahn.** (Zeits. f. Physik, 9. 6. pp. 356–368, 1922.)—An investigation was made of the passage of hydrogen and oxygen canal rays through thin gold foil, and of the effect of varying ray velocity. The canal ray velocity was determined by magnetic deviation methods, and the results showed that the rays in their passage through thin gold foil certainly lose in intensity, but not appreciably in velocity. If positively charged hydrogen canal rays are allowed to fall on the gold foil, below a certain velocity only neutral particles emerge, while secondary electrons are emitted from the back surface of the gold foil. As the velocity is increased beyond this value (about 7500 volts) positively charged particles are transmitted, and the number of these increases rapidly with increase of the canal-ray velocity. With oxygen canal rays the passage of atoms through the gold could certainly be observed, but no charge could be detected after passage through the gold. Two possible explanations of the phenomena are given, and further experiments will be necessary to decide between them. [See abs. 112 (1920).] A. W.

2135. *Operating Characteristics of the Audion.* **L. P. Wheeler.** (Phys. Rev. 19. p. 531, May, 1922.)—In this paper it is shown how the operating characteristics of the audion can be computed from the ordinary static characteristics of the tube which are measured with negligible impedance in the anode circuit. Only the case where the external impedance is a pure resistance is treated. The extension of the results to include reactance can be readily made. The expression by means of which such computations can be made is obtained by transforming the parabolic equation for the anode current in terms of the grid and anode voltages into one in terms of the external and internal resistances of the anode circuit. When this is accomplished, it appears that the operating characteristic can be obtained from the simple static characteristic of the tube without external resistance by multiplying each ordinate of the latter by a numerical factor whose magnitude depends only on the ratio of the external and internal resistances. This factor is a constant for a steady e.m.f., and very approximately constant for an a.c. e.m.f. applied in the grid circuit. Its magnitude varies from unity when the external resistance is zero to zero when the external resistance is infinite. It is further shown how an expression for the a.c. component of the anode current can be obtained when the characteristic is parabolic. From the form of this expression it is seen that in addition to producing distortion the curvature of the characteristic changes the effective resistance of the anode circuit from that which obtains for a linear characteristic. The factor which determines the magnitude of this change also depends only on the ratio of the external and internal resistances, and varies from unity when the external resistance is zero to two when it is infinite. Thus the common statement that the effect of curvature is to introduce harmonics but not to change the magnitude of the fundamental must be modified. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

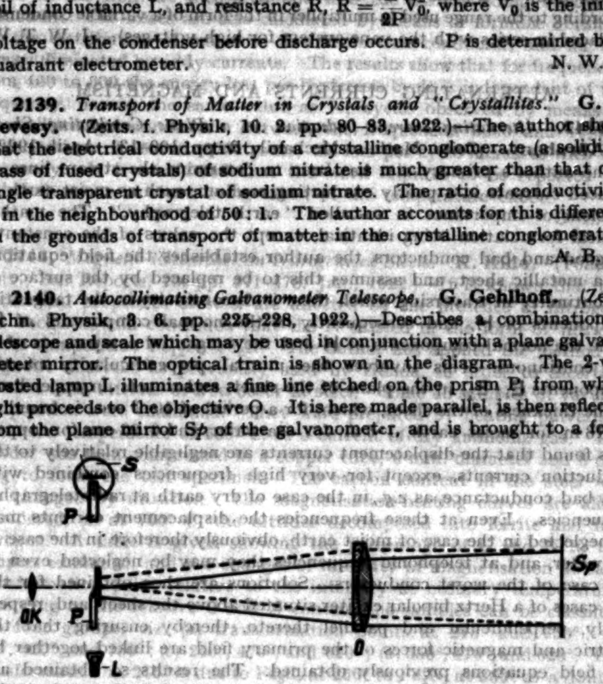
2136. *Relation between Electrical and Thermal Conductivity in Electrolytic Conducting Crystals.* **G. v. Hevesy.** (Zeits. f. Physik, 10. 2. pp. 84–88, 1922.)—Electrolytically conducting crystals of high electrical resistance are found to have good thermal conductivity and vice versa. A. B. W.

2137. *Photoelectric Conductivity of Diamond.* **B. Gudden** and **R. Pohl.** (Zeits. techn. Physik, 3. 6. pp. 199–201, 1922.)—Further experiments have been made with two diamonds, one a very clear specimen, the other with impurities detectable by optical methods. With the first crystal there is a very marked selective effect for incident light of wave-length 226 $\mu\mu$, but the photoelectric conductivity of the impure crystal was very much less, and only showed a slight selective effect in the neighbourhood of 230 $\mu\mu$. The results generally confirm previous work [see Abs. 502 and 915 (1921)]. A. W.

2138. *Measurement of H.F. Resistances.* **P. O. Pedersen.** (Wireless World and Radio Rev. 10. pp. 135–139, April 29, 1922.)—This paper describes a method of determining the H.F. resistance of a coil using damped oscillations. If P is the time integral of the square of the p.d. across the coil of inductance L, and resistance R, $R = \frac{L}{2P} V_0^2$, where V_0 is the initial voltage on the condenser before discharge occurs. P is determined by a quadrant electrometer. N. W. M.

2139. *Transport of Matter in Crystals and "Crystallites."* **G. v. Hevesy.** (Zeits. f. Physik, 10. 2. pp. 80–83, 1922.)—The author shows that the electrical conductivity of a crystalline conglomerate (a solidified mass of fused crystals) of sodium nitrate is much greater than that of a single transparent crystal of sodium nitrate. The ratio of conductivities is in the neighbourhood of 50 : 1. The author accounts for this difference on the grounds of transport of matter in the crystalline conglomerate. A. B. W.

2140. *Autocollimating Galvanometer Telescope.* **G. Gehlhoff.** (Zeits. techn. Physik, 3. 6. pp. 225–228, 1922.)—Describes a combination of telescope and scale which may be used in conjunction with a plane galvanometer mirror. The optical train is shown in the diagram. The 2-volt frosted lamp L illuminates a fine line etched on the prism P, from which light proceeds to the objective O. It is here made parallel, is then reflected from the plane mirror S*p* of the galvanometer, and is brought to a focus again on the glass S, which bears a scale (divisions 0·15 mm. apart). The scale is observed by means of the eyepiece O*k*. As S*p* moves, the image of the line on P moves across the scale on S, but it is always in focus, whatever the distance of S*p* from O. Objective, scale, eyepiece, and lamp are mounted together, and can therefore be moved as a single unit. The advantages claimed are (*a*) autocollimation, (*b*) good illumination with a small lamp, (*c*) reading to 0·1 minutes of arc of movement of the galvanometer mirror, (*d*) compactness. J. W. T. W.



2141. *Simple Electrostatic Voltmeter.* **J. E. Shrader.** (Optical Soc. America, J. 6. pp. 273–278, May, 1922.)—Describes an instrument which is a modification of the Braun electrostatic voltmeter, operating on the principle of electrostatic repulsion between a stationary and a movable vane. The movable vane is made of thin sheet aluminium, and is held parallel to the stationary vane by a torsional suspension held under tension at both ends. The instrument illustrated in the paper is suitable for 2000 volts, and if the case is filled with insulating oil it may be used up to 10,000 volts. The advantages claimed for the instrument are: (1) Accuracy of reading and permanence of zero, (2) good damping, (3) small electrostatic capacity, (4) ruggedness and simplicity. A deflection of 400 mm. on a scale 1 m. distant will indicate 1400 or 12,000 volts according to the range used (a multiplier in the form of a variable condenser is placed in series with the vane system for high voltages). J. W. T. W.

ALTERNATING CURRENTS AND MAGNETISM.

2142. *Alternating-Current Induction in a Plane Conducting Sheet.* **M. Abraham.** (Zeits. Math. u. Mechanik, 2. pp. 109–131, April, 1922).—The author's primary aim has been to determine the stream lines of induced currents in a poorly conducting medium, such as moist earth, a problem of importance in so-called "earth telegraphy." The mathematical formulation being identical, except the values of the constants, for good and bad conductors, the author establishes the field equations for a metallic sheet, and assumes this to be replaced by the surface of discontinuity in traversing which there is discontinuity in the tangential components of **H**, and consequently in the normal components of **E**, while the normal components of **H** and the tangential components of **E** are continuous. This involves the mutual perpendicularity of the components $\mathbf{E}_x$, $\mathbf{E}_y$, in the plane of the sheet, and so sets an upper limit to the thickness of the sheet, which, for a period of 10^{-3} sec., is found to be 16 m. for moist earth, 1·6 m. for sea-water, and 0·02 cm. for copper. It is found that the displacement currents are negligible relatively to the conduction currents, except for very high frequencies combined with very bad conductance, as, *e.g.*, in the case of dry earth at radiotelegraphic frequencies. Even at these frequencies the displacement currents may be neglected in the case of moist earth, obviously therefore in the case of sea-water, and at telephonic frequencies they may be neglected even in the case of the worst conductors. Solutions are then obtained for the two cases of a Hertz bipolar exciter situated above the sheet, and, respectively, perpendicular and parallel thereto, thereby ensuring that the electric and magnetic forces of the primary field are linked together by the field equations previously obtained. The results so obtained are generalised by considering a linear exciting current as built up of a series of these bipolar exciters. Solutions are thus obtained for the currents induced in the sheet by an alternating current in, (1) a straight linear conductor of finite length lying close to or within the sheet, (2) by a coil with its axis, respectively, perpendicular and parallel to the sheet. (1) Is the solution of the problem occurring in earth telegraphy. The solutions (2) are obtained by considering the coil as represented by a bipolar magnetic exciter, the magnetic moment of which undergoes periodic variation. Finally, solutions are obtained for the special case of the coil lying close to, or within, the sheet, and it is shown that when the axis is parallel to the sheet the coil may be of finite length. Five sets of streamline curves are given in the paper. G. W. DE T.

2143. *Losses in Iron at High Frequencies.* **E. Brasey.** (Arch. des Sciences, 4. pp. 157–202, May–June, 1922.)—Recent researches have made it evident that to obtain the hysteresis loss in iron subjected to oscillating fields, free from error due to eddy currents, the iron must be subdivided to make the eddy-current loss negligible. Such experiments have established that the energy dissipated per hysteresis cycle is independent of the frequency [see Abs. Nos. 3006 (1904) and 1145 (1914)]. The author describes experiments made on a ring of iron wire of diameter 0·236 mm. subjected to fields of frequencies up to 10,000; the total losses in the iron are measured and also the corresponding maximum induction. The losses are also calculated by means of formulæ obtained for the distribution of magnetic flux in an iron conductor, and for the energy dissipated by eddy currents. The results show that for frequencies from 400 to 600 the energy loss per hysteresis cycle is independent of the frequency, having the same value as for cycles observed by means of the ballistic galvanometer. Between the frequencies 3000 and 10,000, for inductions of 1500 to 3600 gauss, the loss per cycle increases with the frequency. It is considered that the work requires to be repeated for high inductions, account being taken of the temperature effect.

G. E. A.

2144. *Magnetic Researches on Nitrogenised Steels.* **K. Kido.** (Tohoku Univ., Sci. Reports, 10, pp. 471–478, Jan., 1922.)—It is known that the mechanical properties of steel are affected by the presence of nitrogen, and Tschischewski concluded that the N existed in the form of nitrides of the composition $Fe_{12}N$, Fe_2N. The author has applied the method of magnetic analysis, as previously used by Honda, in order to ascertain in what form nitrides of iron occur in steel. Some 45 samples of varying composition were examined. They were prepared by heating pulverised steel to a temperature of 650° C. in a current of dry ammonia gas. The powder was then compressed in a copper tube, 6 mm. diameter and 8 cm. long to form the test specimen. The carbon content in the steel was not changed by nitration. The magnetisation-heating curves are alone considered, as at 700° C. the nitrides decomposed into ferrite and free nitrogen. A table is given showing the percentage of C and N in the samples examined, and the changes of intensity of magnetisation at each transformation point relative to the intensity at ordinary temperature. According to the relative C and N content the samples can be classified into four groups, viz. (*a*) transformation points at 215° and 750°; (*b*) 470°, 620°, and 750°; (*c*) 250°, 470°, and 620°; (*d*) 350°, 470°, and 620°. The transformation at 215° is due to Fe_3C, at 250° to Fe_2N, at 350° to a double carbide of Fe and N, at 470° to $Fe_{12}N$, and at 620° to a second double carbide. The double carbides whose formulæ have not yet been fixed are new.

L. L.

2145. *Special Form of Terrestrial Magnetic Disturbances.* **L. Steiner.** (Terrest. Magn. 26. pp. 1–14, March–June, 1921. Abstract of paper read before Hungarian Acad. Sci., Budapest, Jan., 1921.)—This paper deals with small disturbances of regular course and of duration 1½ to 2½ hours, which often occur on quiet or almost quiet days. The Ogyalla records for the years 1906–17 show 531 such cases in 428 of which the horizontal intensity is augmented (Class I), and in 103 diminished (Class II). In the annual variation of frequency there appears to exist a double wave. The diurnal variation of frequency differs greatly in the two classes. Throughout the year disturbances of Class I show a max. about 10 p.m. to midnight (local time), and occur very rarely during the eight hours centring at noon. Those of Class II are very rare at night and during the morning, and are of max. frequency in late afternoon. The disturbing forces show two marked features. The horizontal component of the disturbing force perpendicular to the magnetic meridian is directed in the afternoon and evening towards magnetic east; in the morning towards west. The vertical disturbing force is generally negative in Class I and positive in Class II; further, to a greater absolute value of the horizontal disturbing force corresponds a greater absolute value of the vertical disturbance.

The author concludes that on the whole there is an analogy between the disturbances of Classes I and II and the negative and positive polar storms of Birkeland. They cannot, at any rate, on such simple assumptions, be explained on the supposition that the magnetic disturbances are due to positive particles. M. A. G.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

2146. *The Efficiency of the Bucky Diaphragm Principle.* **R. B. Wilsey.** (Röntgen Soc., J. 18. pp. 77–89, April, 1922.)—Using a 6-inch depth of water as the scattering material the efficiency of the Bucky diaphragm in removing scattered radiation has been measured for a variety of widths and depths of slit. This diaphragm was found to be highly efficient, it being easily possible to remove more than 80 per cent. of the scattered radiation. The definition obtainable depends chiefly on the distance between the subject radiographed and the film; by making this distance sufficiently small the Bucky diaphragm can be made to give a considerable improvement in definition over the ordinary technique, and can be used with advantage in radiographing thicknesses as small as four inches.
W. R. C.

2147. *How to Prepare for 200,000 Volts in Radiology.* **A. E. Dean.** (Röntgen Soc., J. 18. pp. 72–76, April, 1922.)—Means for protecting the operators are considered.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2148. *Atomic and Molecular Volumes at Absolute Zero.* II. **W. Herz.** (Zeits. anorg. Chem. 119. pp. 221–224, Nov. 3, 1921.)—The relation between molecular volume of a compound and the atomic volume of the constituents should be determined for absolute zero temperature (R. Lorenz and Herz, *ibid.*, 117. pp. 267–270). When this is done for alkali salts, the molecular volume is smaller than the sum of the atomic volumes, the contraction being greatest for the formation of CsF (60 %) and greatest for the same alkali in the case of the fluoride and least for the iodide. In the hydrogen halides the molecular volume is smaller than the sum, but the difference becomes smaller as the atomic weight of the halogen increases, the difference being 7·52 for HF., 9·09 for HCl, 1·09 for HBr, and 0·01 for HI. In the trihalides of the metals of the fifth group the relation is reversed, the molecular volume being greater than the sum of the atomic volumes. Calculations based upon the dielectric constant after Clausius-Mossotti may give greater or smaller values than the actual molecular volumes.

H. B.

2149. *Molecular Volumes and Models of the Halogens and their Physical Properties.* **F. A. Henglein.** (Zeits. anorg. Chem. 118. pp. 165–171, Aug. 8, 1921.)—W. Biltz (*ibid.*, 115. pp. 241–252, and 117. pp. 84–90, 1921) having shown that there is a linear relation between the molecular volumes of the halogens and of their compounds, the author, making use of known data, finds that this holds also for the atomic volumes at their boiling-points and for various properties, melting- and boiling-point, critical temperature, heat of fusion and evaporation, and normal potential, and may be traced to the simple structure of the halogen molecule. The halogen atom has 7 valency electrons, and the molecule can be represented by two cubes having one edge, and hence two of these twice 7 electrons (at the corners), in common. H. B.

2150. *The Corrosion of Iron.* **J. N. Friend.** (Iron and Steel Inst., Carnegie Schol. Mem. 11. [156 pp.], 1922.)—This monograph consists of a collected series of papers by the author on different aspects of the problem of corrosion. Part 1 is a critical survey of present knowledge, while Part 2 deals with the protection of iron by paint against subaqueous corrosion. Part 3 discusses the influence of strain on corrosion, and Part 4 that of temperature. Part 5 reviews the colloidal theory of corrosion, while in an Appendix is given a preliminary report on the relative corrodibilities of commercial irons and steels. The colloid theory of corrosion is considered to explain satisfactorily many phenomena previously unexplainable and to suggest new lines of research as regards protection from oxidation. L. H. W.

2151. *Some Fundamental Conceptions of Colloid Chemistry. II. Electrical Charge on Particles and the New Term "Micelle."* **R. Zsigmondy.** (Zeits. phys. Chem. 101. pp. 292–322, 1922.)—A résumé is given of the existing knowledge on the state of aggregation of colloidal matter. The most characteristic property exhibited by colloids is the electrical charge of the ultra-micron particles due—according to the theory adopted in this paper—to adsorption of ions in a manner which is not clearly understood. Stabilisation of a colloid by an added body is generally accompanied by an increase of the electrical charge of the suspensoid and removal of the charge produces coagulation. Colloids may consist of primary crystalline particles, such as colloidal gold, V_2O_5, etc.; secondary complexes, as in colloidal stannic acid and Purple of Cassius; or in aggregates of molecules and ions of transient stability. In all cases, these formations may be combined in condensation nuclei, as in soap solutions.

The term "micelle" is now employed generally to denote adsorption complexes which undergo dissociation into simple anions and a complex kation group, or into simple kations and a complex anion group. A typical instance is the association of ferric oxide with $FeCl_3$ to give a complex of the composition: $Fe_{(x+y)}(OH)_{3x}Cl_{3y}$. By changing the conditions of formation of a colloidal solution the size of both primary and secondary particles can be varied and a great diversity of properties thus obtained. As the concentration of a peptising agent increases, the degree of subdivision of the secondary particles rapidly increases and, at the same time, a reduction follows in the ratio of mass to charge. The smaller this ratio becomes, the more the colloidal solution resembles an electrolyte and very small colloidal particles can hardly be distinguished from ions. In the case of V_2O_5, a definite crystalloid solubility has been established, the smaller particles being more soluble than the larger. The crystalline structure has been verified by X-ray interference phenomena. On adding to the sol gradually increasing amounts of HCl and observing under the ultra-microscope, the separation of needle-shaped crystalline particles is seen first. This is followed by turbidity of the medium and gel formation and the appearance of clusters under the ultra-microscope and finally with more acid the colloid disappears as a true crystalloid solution. It is found with micelles that on removing the crystalloid components by means of ultra-filtration the colloidally dissolved residue has a definite conductivity through dissociation. In many cases, the anomalous relation is found that the conductivity and more particularly the osmotic pressure, increase more than proportionately to the concentration of colloid.

The properties of micelles have been investigated most extensively in the case of Na or K salts of the fatty acids of medium and high molecular weight. These form amicroscopic micelles which contain negatively charged colloidal particles. Very dilute solutions of these are essentially normal electrolyte solutions and able to pass through parchment membranes. The higher the concentration and molecular weight of the soap the more the solutions partake the properties of colloids due to the formation of micelles at the expense of the soap molecules. The progress of the formation of these complexes is concomitant with increase in viscosity, susceptibility of coagulation by electrolytes, protective power towards colloidal gold, lowering of surface tension, lather formation, and cleansing action. Measurements made by McBain and Salmon on the lowering of vapour pressure and the conductivity to determine micelle formation show that with alkali salts of fatty acids of low molecular weight, the carriers of electricity are entirely ions in the case of dilute solutions, and chiefly micelles in the case of concentrated solutions. The composition of the micelle in the case of Na palmitate is $(NaP)_x(P)_n^{n(-)}.(H_2O)_m$ where P^- is the anion of palmitic acid. In dilute solution, the component (NaP)$_x$ is small, so that the ionic micelle consists of an aggregate of the palmitic anion with water. In modification of the above theory it would appear that, at least in concentrated solutions, hydrolysis of the salt occurs and the free acid enters as a component of the micelle. The presence of the free acid can be first seen as submicron particles on diluting the solution. It has been shown experimentally that during electrolysis of Na palmitate solutions Na migrates to a considerable extent to the anode. Soap micelles differ from those of colloidal metallic oxides in their instability in changing their composition with concentration and temperature. They pass through collodion films, but are held by membranes with pores sufficiently fine to hold congo-red. J. N. P.

2152. *Improvement of Aluminium by Molybdenum Alloys.* **H. Reimann.** (Zeits. f. Metallkunde, 14. pp. 195–203, May, 1922.)—The attempts to improve Al by the addition of Mo not having proved promising [Abs. 1927 (1922)], the author tries ternary alloys of Al and Mo with Mg, Zn, Cu, or Ni. The Mo percentage did not exceed 1; of the last-mentioned metals, up to 3 and 10 % were used, the main metal in the alloys being Al. The tests concern the usual strengths, casting, machining, hardness, behaviour as bearing material, and rolling; metallographic and electric conductivity tests are also made. The results varied; in some cases the additions reduced the strength, and the main object, shortening of the fusion interval and prevention of segregation, was not realised. But this particular object might be attained by other additions, and some of the alloys certainly improved the aluminium. H. B.

2153. *Explanation of the Inverted-Block Segregation.* **G. Masing.** (Zeits. f. Metallkunde, 14. pp. 204–206, May, 1922.)—Bauer and Arndt [Abs. 1761 (1922)] have observed that alloys, consisting in the equilibrium state of homogeneous mixed crystals, may, on rapid cooling, show unexpected changes in concentration, the constituent which ought to segregate last, and hence in the core of the ingot, being found concentrated on the outside; the author suggests an explanation. According to Noyes, Nernst, and Brunner, the mass-velocity of dissolution and crystallisation mainly depends upon diffusion, and the author shows that the impedance of diffusion by under-cooling would have the effect mentioned. **O. Bauer** (*ibid.*, p. 206), in reply, does not consider that under-cooling would account for his observations. H. B.

2154. *The Inner Structure of the Pearlite Grain.* **N. T. Belaiew.** (Iron and Steel Inst., J. 105. pp. 201–227; Disc. and Corres., 228–230, 1922. Engineering, 113. pp. 634–638, May 19, 1922.)—In a sample of steel there appears to be a great difference in the coarseness of the pearlite in different grains which have evidently been subjected to similar heat treatment, the distance between the cementite lamellæ varying in a ratio of 1 to 10 or even 1 to 15 in adjacent grains. Assuming that a secant plane would meet a multitude of grains under all kinds of angles, it is evident that the coarseness of the pearlite, besides the actual size of cementite lamellæ and the distance between them, will depend on the position of the secant plane, as what is actually seen is a projection of the lamellæ on that plane. All conditions being equal, pearlite of a certain degree of development will be better seen on the slide, the smaller the angle between the former and the longest axis of the cementite lamellæ. The arrangement of the lamellæ in a pearlite grain is roughly parallel one to another and to the crystallographic plane of the grain, presumably to one face of the cube. A secant plane perpendicular to that face will be normal to the lamellæ and the angle of inclination for that plane will be zero. All the lamellæ of the grain will be seen on the normal plane and the distance between two lamellæ will be the actual distance. As the angle of inclination increases, the number of lamellæ seen on a section of the same grain decreases and the apparent distance between two lamellæ increases. When the angle of inclination approaches 80° the distance between the lamellæ becomes 5 times greater than with zero inclination at 84°, 10 times greater and at 87°, 20 times greater. Formulæ are given in the paper for the calculation of the angle of inclination and the actual distance between two lamellæ. This latter is of importance in every pearlite steel and may be taken as a measure of the thermal conditions during the Ar1 transformation.

Values for distances between lamellæ of different steels are given varying from 100 $\mu\mu$ to 350 $\mu\mu$, and for diameters of cementite lamellæ varying from 25 $\mu\mu$ to 90 $\mu\mu$. A suggestion is made as to the interior structure of the pearlite grain. C. O. B.

2155. *Metallographic Criterion of the Temperature to which Mild Steel has been Reheated.* **P. Oberhoffer.** (Stahl u. Eisen, 41. pp. 1215–1217, Sept. 1, 1921. Rev. de Mét. 19. E. pp. 312–313, June, 1922.)—Having shown (*ibid.* 40. p. 1433, Oct. 25, 1920) that the degree to which some technical cast steels have been reheated can be recognised by metallographic examination, the author finds that in this way it can also be ascertained whether a mild steel, with from 0·07 to 0·12 % C, *e.g.*, a boiler plate steel with 0·09 C, 0·53 Mn, 0·03 P, and 0·036 S, has been reheated to temperatures between Ac_1 and Ac_3. The specimens (impact test bars) were heated for half an hour to various degrees and then cooled in air. So long as the temperature keeps near 700° (below Ac_1) or above Ac_3, 950°, the examination does not reveal any particular novel features. But near 800° the islets of pearlite show border spots of ferrite which are not separated from the other ferrite by distinct lines, but stand out in relief when the specimen is etched; why, is not clear. The photographs are magnified 900 times, but a magnification of 100 suffices to bring out the peculiarity. H. B.

2156. *Generalisations on Quenching Phenomena.* **L. Guillet.** (Rev. de Mét. 19. pp. 162–177, March, 1922.)—A discussion on the relationship existing between the equilibrium diagram and the effect of quenching. Taking the diagram as the basis of discussion, three classes of alloys are considered: (1) Alloys containing an eutectoid. (2) Alloys having a transformation line separating a single-phase area from a two-phase one. (3) Alloys occurring in a two-phase area bounded by two irregularly curved lines.

(1) *Case of the Eutectoid.*—For a quench to be complete, the alloy must be in the homogeneous field above the eutectoid line. With a maximum quenching effect, this homogeneous solution is retained, and the metal is comparatively soft (austenite). With less vigorous quenching a mixture of the solid solution and one of the constituents of the eutectoid is obtained (martensite). This gives a maximum hardness. Still less

vigorous quenching gives a constituent which appears to consist of the eutectoid in a state of very fine division, or possibly in a colloidal state (troostite). Some, or all, of these phases are met with in steels, bronzes, brasses, and aluminium-copper alloys.

(2) *Transformation Line Separating a One-Phase Field from a Two-Phase Field.*—This is divided into two cases, according as the single-phase field is the upper or the lower one. In the former case, quenching may preserve the single phase, while if it is followed by annealing precipitation of the second phase in a very fine state of division may result, giving rise to an increased hardness.

(3) *Two-Phase Field Bounded by Curved Lines.*—Quenching an alloy in such a field gives rise to a change in the proportion of the constituents. If the quenching is followed by annealing, a reprecipitation of one of the constituents in a fine state of division may result. The hardening of certain Al-Cu alloys is an example of this result.

The influence of quenching and annealing on the hardness of alloys of aluminium with silicon; magnesium; silicon and copper; silicon and magnesium; and silicon, magnesium, and copper is studied. J. L. H.

2157. *Solubility Limits of Carbon in Ternary Steels. I. The System Chromium-Iron-Carbon.* **K. Daeves.** (Zeits. anorg. Chem. 118. pp. 55–66, Aug. 8, 1921.)—As chromium is added to steel the solubility of the carbon falls off, rapidly at first and then more slowly, the curve being hyperbolic. The author's materials were Swedish charcoal iron with 4·2 % C, electrolytic iron, and a ferrochrome with 65 % Cr and 0·93 % C. He adds ferrochrome in steps of 1 or 2 per cent. until he obtains one melt with a eutectic, and another without eutectic. The operation is then repeated with a different C percentage until the products contain hardly any eutectic; the solubility curve is thus made more definite. For the micrographic studies the very hard specimens had to be reheated to 800° for many hours before they could be drilled and sawn. The specimens were first etched with sodium picrate; but the cementite remained white, so that the Murakami etching agent (2 parts of ferric potassium cyanide, 25 of caustic soda, 75 of water) was used, which colours the eutectic yellow-brown, leaving the mixed crystals unchanged. All the alloys were magnetic. The solubility curve helps to explain many peculiarities of the properties of the alloys, for which Guillet's diagrams, deduced from forged specimens, did not account. When in Cr steels the solubility limits of carbon are exceeded, the steel becomes inhomogeneous, eutectic segregating after the manner of slag enclosures. Like Goerens and Staedeler, the author finds that Cr up to 10 % does not much affect the melting-points nor the arrest-points of the steels.

II. *The System Tungsten-Iron-Carbon* (*ibid.*, pp. 67–74, Aug. 8, 1921.)—The similar experiments gave similar results. Nineteen melts were made in kryptol furnaces. As in the case of chromium, the addition of tungsten prolongs the eutectic line in the direction of the iron side. The so-called double carbides, said to be formed when the percentage of Cr or W exceeds a certain value, are present in the unworked melt in the form of a eutectic, and are hence connected with the solubility curve of carbon, which is decisive for the properties of the steels. The melting-point of steel seems to be raised by the addition of a little tungsten, but lowered by further additions. The alloys contained up to 16·8 % W. H. B.

2158. *The Constitutional Diagram of the Iron-Carbon System.* **K. Honda.** (Iron and Steel Inst., J. 105. pp. 381–390; Disc. and Corres. 391–392, 1922.)—A review of recent work on graphitisation in iron-carbon alloys, the shape of the liquidus and solidus in the diagram, and the meaning and temperature of occurrence of the A_4, A_3, A_2, A_1, and A_0 transformations. It is suggested that the A_2 and A_0 transformations are not phase changes, but merely the end points of changes which are progressive with temperature. A diagram, based on the deduced results, is given. J. L. H.

2159. *Growth of Grey Cast Iron during Repeated Heatings and Coolings.* **T. Kikuta.** (Iron and Steel Research Inst. 57th Report. Tôhoku Univ. Sci. Reports, 11. pp. 1–17, April, 1922.)—In view of the fact that the explanation regarding the growth of grey cast iron are not very satisfactory, a further investigation was undertaken, the results of which are given. If the continuous growth of cast iron during repeated heatings and coolings be due to the pressure of occluded gases, it is necessary to assume that at low temperatures, the gases penetrating along the graphite flakes and remaining inside, cannot escape at high temperatures, the iron becoming in these ranges compact. The results of leakage experiments after varying numbers of heatings and at different temperatures show that the leakage rate of air through a hollow cylinder, increases slowly up to 25 heatings, from 25 to 58 heatings it increases very rapidly and afterwards decreases. The leakage rate of air is almost constant for the first 20 heatings up to 900° and from 21 to 34 heatings increases slightly with the rise of temperature up to 950°. During further heatings, the rate decreases at first, reaches a minimum at 730°, and then slightly increases. From the results obtained, the above assumption is held to be untenable. The results of density determinations after different heat treatments are given, and as the density after continual heatings in air show larger decreases than those after repeated heatings in vacuo, it is concluded that oxidation makes some contribution to the growth. The specimens, repeatedly heated in vacuo, show considerable decrease in density, therefore, oxidation cannot be the main cause of growth.

The thermal dilatation of grey cast iron in vacuo, in hydrogen, and in air was re-examined and the following explanations of the growth are given in the paper:—The growth of grey cast iron during the first heating through 700° to 800°, is partly attributable to the decomposition of cementite. The continuous growth in a vacuum during repeated heating and cooling through the A_1 range is the effect of the differential expansion at different microportions of the same specimen, numerous fissures or cavities being thus formed in the region of graphite flakes. In an oxidising atmosphere, the growth is accelerated by oxides formed and filling the fissures or cavities during A_1 transformation. Thus the effect of oxidation on the growth of cast iron is indirect. The elongation observable at higher temperature than the A_1 point is due to the pressure of occluded gases, as conceived by Okôchi and Satô. It is finally concluded that from the results of the present investigation, the oxidation theory put forward by Rugan and Carpenter seems to be untenable. [See Abs. 1214 (1920).] C. O. B.

2160. *Aluminium Zinc Alloys.* **D. Hanson** and **M. L. V. Gaylor.** (Inst. of Metals, J. 27. pp. 267–294; Disc. and Corres. 295–306, 1922. Engineering, 113. pp. 538–540, April 28, and pp. 666–667, May 26, 1922.—

Abstract.)—A study of the constitution and age-hardening of the alloys of aluminium and zinc. *Constitution.*—After referring to the work of earlier investigators on the constitution of the system, the present investigation is described, and a revised equilibrium diagram is put forward. This differs from the diagram of Rosenhain and Archbutt, (1) in representing the β phase, not as the compound Al_2Zn_3, but as a solid solution occurring over a considerable range of temperature and composition and decomposing eutectoidally at 256 deg. C.; (2) in defining the limits of the γ and $\alpha + \gamma$ fields and, (3) as showing the existence of a $\beta + \gamma$ field between β and γ. The stability of the β phase was especially studied, and it was found that, though alloys could be preserved as pure β by suitable quenching, yet decomposition was found to take place immediately after quenching if the alloy was kept at room temperature. Specimens of an alloy containing 77 % Zn were quenched from 370 deg. C. polished and then etched 1·5, 2, 5, and 10 minutes after quenching. The first of these was homogeneous, and consisted of pure β. The second and third consisted of dark and light patches, the light being unchanged β while the dark was presumably $\alpha + \gamma$. The fourth specimen etched completely dark and was apparently entirely $\alpha + \gamma$. The decomposition of β was accompanied by a considerable evolution of heat, and specimens consisting largely of β after quenching, rose in temperature by as much as 50 deg. C. on being left in the air.

Age-hardening.—Hardness measurements were made on a number of alloys consisting mainly or wholly of β. The hardness measurements were made immediately after quenching, and then at intervals, which were measured by seconds in some cases; it was found that the hardness rose for the first five or six minutes (the hardness number becoming more than doubled) and then fell off steadily, the hardness curve approaching asymptotically to a value which is apparently greater than the hardness immediately after quenching. Specimens left in ice after quenching behaved in a similar way, though the time taken by the reaction is greater under these circumstances. Alloys consisting of γ were treated in the same way, and it was found that they behaved similarly, though the effect was very much less marked. J. L. H.

2161. *Change of Structure in Silver above 500° C.* **M. Kahanowicz.** (Accad. Lincei, Atti, 31. i. pp. 313–315, April 23, and pp. 364–366, May 7, 1922.)—Describes the results of experiments on the properties of silver as the temperature is raised to 1227° K. The investigation includes measurements of emissive power, resistance-temperature coefficient, and thermo-electric e.m.f. In each case it was found that the metal behaved normally up to a temperature of about 570° C., but that above this point a marked modification in values took place, indicating a gradual change of internal structure. This change is demonstrated by microphotographs, reproduced in the paper. At 800° C. the elements of a cellular structure begin to appear, and large crystals are found at 870° C. J. W. T. W.

2162. *Synthesis of Ammonia by the Impact of Slow Electrons.* **E. B. Andersen.** (Zeits. f. Physik, 10. 1. pp. 54–62, 1922.)—A spherical-shaped glass vessel of about 800 cc. capacity was provided in the middle with two parallel rectangular platinum plates separated by an interval of 5 mm. In the space between these plates which served as anode, a loop of tungsten wire was connected as kathode and served as a source of electrons. The glass vessel was fitted with an inlet tube for admitting

gases and connected with a McLeod gauge for the measurement of pressure and with a vessel containing sulphuric acid for the absorption of ammonia. With a mixture of N_2 and H_2 in the theoretical proportion to give NH_3, admitted to the vessel to give an initial pressure of 0·15 mm. and submitted to an electronic current of 1 milliamp. at 26 volts, the pressure fell to 0·10 mm. after 70 mins., the change representing the amount of NH_3 formed. The electronic current was kept at any desired constant amount during the experiment by regulating the heating current. By varying the P.D. to maintain a constant current, the formation of NH_3 first became appreciable at 18 volts and from this point the increase gave a periodic relation with the P.D. which remains unexplained. The formation of NH_3 also increased with the proportion of N_2 up to a content of this gas from 90 to 94 %. This is in accordance with the view that N_2 becomes activated by the electronic current and leads to the reaction.
J. N. P.

2163. *Crystallisation Velocity under High Pressure.* **M. Hasselblatt.** (Zeits. anorg. Chem. 119, pp. 325–352, Nov. 15, 1921.)—The author modifies the apparatus of Tammann—steel cylinder with a bore of 6 mm. diam. in which a steel piston is loaded up to 1000 or 2000 kg./cm^2.—in order to study the crystallisation velocity c.v. of 13 substances, thymol, benzophenone, salol, and various nitrates (Ca, Cd, mixtures); some of the substances existed in two modifications. The relative influence on the c.v. bears no simple relation to the melting-point and to the max. pressure and is on the whole surprisingly small. The curve c.v./bath temperature does not change in type with increasing pressure; the range for which the c.v. is independent of the undercooling, is shifted, like the melting-point, up to higher temperatures. In one case the c.v. was raised by the pressure increase of 1000 kg. by 43 %, in another case it was lowered by 49 %; in most cases the c.v. was very slightly lowered. Considering that with increasing pressure the range of the crystallisation temperature is likewise raised, it may be assumed that increase of pressure alone would always lower the c.v. The influence on the pressure relations of the addition of various (mostly organic) substances to benzophenone was small.
H. B.

2164. *Chemical Reaction Limit of Copper-Gold Alloys and their Potentials.* **G. Tammann.** (Zeits. anorg. Chem. 118. pp.48–54, Aug. 8, 1921.)—The experiments are made with anodes of the alloys against kathodes of gold in various electrolytes (copper sulphate, caustic potash and potassium sulphide, potassium cyanide, etc.), and also against kathodes of silver in silver sulphate. When more than 2/8 of the alloy is gold, no copper is dissolved, and the alloy behaves electrically like pure gold. The silver salt deposits silver on the alloy only as long as the gold proportion is below 0·145, and the alloy then takes a negative charge; when the alloy is richer in gold, the charge is weakly positive, suggesting that the surface atoms of copper are set with silver atoms so that the surface behaves as if it were an Ag-Au alloy of the original gold concentration; on the poorer gold alloys the conditions are more favourable for the crystallisation of silver.
H. B.

2165. *Influence of the Time Factor on the Interpenetration of Solids by Chemical Reaction.* **H. Weiss and P. Henry.** (Comptes Rendus, 174.

pp. 1421–1423, May 29, 1922.)—Further experiments [Abs. 1779 (1922)], with silver-antimony and copper-antimony, are described. The time required for a given increase in the thickness of the zone of interpenetration of two metals is divided into: (1) The duration of the chemical reaction after contact of the molecules of the two metals, this being independent of the thickness of the layer already formed, and (2) the time necessary for the molecules to traverse such layer, this being proportional to the thickness of the latter. The experimental results obtained indicate that the duration of the chemical reaction is negligible in comparison with the time occupied in the passage through the layer formed. At each of the various temperatures employed, the experimental points are situate on two distinct curves, which are clearly related to the intensity of the blows by means of which contact between the two metals was established. T. H. P.

2166. *The Fusion Diagram of Mixtures of Cadmium and Calcium Nitrates at Pressures from* 1 *to* 3000 *kg./sq. cm.* **M. Hasselblatt.** (Zeits. anorg. Chem. 119. pp. 313–334, Nov. 15, 1921.)—Particulars given of experiments with mixed crystals of $Cd(NO_3)_2$, 4 ag. + $Ca(NO_3)_2$, 4 ag. The two salts form a continuous series of mixed crystals; there is, however, a more stable modification of the Ca salt which does not yield mixed crystals with the Cd salt. This latter modification forms by spontaneous crystallisation when $Ca(NO_3)_2$ predominates; when the melt is undercooled and inoculated with the Cd salt, the less stable crystals appear. In the presence of both crystals a eutectic point with 91 % $Ca(NO_3)_2$, 4 aq. occurs at 40·6°. The melting-point of the Ca nitrate at 1 kg. and 3050 kg./cm.^{2} is 42·5° and 68·95°, that of the Cd nitrate at 1 kg. and 2860 kg. 59·3° and 78·5°. As the melting-point of the stable Ca-salt rises more rapidly, with increasing pressure, than the melting-point of the mixed crystals, the eutectic point is shifted with increasing pressure. H. B.

2167. *Solidification Diagram of Zinc-Arsenic Alloys.* **W. Heike.** (Zeits. anorg. Chem. 118. pp. 264–268, Sept. 5, 1921.)—The previous experiments of Friedrich and Leroux dealt only with alloys containing up to 13·8 % As. The author fuses zinc and arsenic in an evacuated electric furnace and obtains alloys containing from 6·6 up to 92 % As. There are two compounds, both very brittle, Zn_3As_2 (melting-point 1015°) and $ZnAs_2$ (m.p. 771°); the latter has a transformation point at 671°; both melt without decomposition. Alloys of more than 70 % As are made in a strong porcelain vessel (wall thickness 1 cm.) embedded in sand. As the As increases, the solidification begins at higher temperatures (725° to 1015° for up to 43·43 % As) and then at lower temperature (743° and 795°, for 84 and 92 % As); the end of the solidification takes place at 419° in the former case and near 750° in the latter. Zn_2S_3 shows supercooling in solidifying; it does not form any solid solution, and it hardly dissolves any zinc; but As is soluble to a considerable degree in ZnS_2. The solidification diagrams of Zn-As and Cd-As are very similar. H. B.

2168. *Influence of Pressure on Spontaneous Crystallisation.* **M. Hasselblatt.** (Zeits. anorg. Chem. 119. pp. 353–364, Nov. 15, 1921.)—The apparatus mentioned in Abs. 2163 (1922) is used. The substance is fused in a stout glass capillary of 0·4 mm. bore, closed above by a thread of mercury. The exposure (compression) takes up to 10 minutes, the removal up to 1 minute. The number of crystallisation centres or germs is counted, if necessary, after "developing" in a bath of higher temperature in which the germs would develop to microscopic visibility, whilst no new germs would be formed. Experiments with betol, piperine, and papaverine show that the pressure rise (1000 kg./cm.^{2}) raises the melting-point and the temperature of maximum spontaneous crystallisation by corresponding amounts. As to the number of germs, different specimens and experiments varied much, but the forms of the curves changed little. Thus betol at 1 kg. behaved much like betol at 1000 kg. and a temperature of 20° to 25° higher; betol melts at 93° and 122·9° at the pressures mentioned. In the case of piperine (m.p. 1290°) the number of germs was doubled by the high pressure; with papaverine the maximum number of germs was not changed by the high pressure, but the temperature of the maximum was raised by the increasing pressure from 40° to 60°.

H. B.

2169. *Conditions of Stable Equilibrium in Iron-Carbon Alloys.* **H. A. Schwartz, H. R. Payne, A. F. Gorton,** and **M. M. Austin.** (Am. Inst. Mining Eng., Trans. [12 pp.], 1922.)—Contains the results of the study of a white iron as used for malleable castings, including the determination of thermal critical points in the stable and unstable condition, the results of the microscopical study of solid solutions of the two systems, chemical investigation of solubility of carbon in the stable system as related to temperature and a study of changes in electrical resistance accompanying graphitisation. The results obtained indicate that the solid solutions of the stable system are distinct in structure, electrical properties, and temperature-solubility relation from those of the metastable system and for the stable solid solution the name boydenite is suggested. It is also suggested that austenite is a solution of cementite in iron and boydenite is a solution of carbon.

C. O. B.

2170. *The Stepped A1 Transformation in Carbon Steels during Rapid Cooling.* **K. Honda** and **T. Kikuta.** (Iron and Steel Inst., J. 105. pp. 393–405; Corres., 406–407, 1922.)—The well-known fact that the position of the A1 transformation in steel is lowered by increasing the velocity of cooling to 600° and by a further increase of velocity of cooling is reduced discontinuously to 300° and also that by intermediate velocities of cooling the two transformations may take place during a single cooling receives further attention. During the intermediate velocities of cooling, the two transformations obtained are usually designated Ar′1 and Ar″1, and these are explained by some metallurgists as being of quite different natures and by other metallurgists as being of the same nature the Ar″1 transformation being merely the retarded Ar′1 transformation. The results of experimental examination by means of the magnetic and dilatometric methods of chromium steel, 10 % Cr, and nickel steel 10 % Ni are given together with results of experiments on a 0·4 % carbon steel. By the magnetic method it is shown that the chrome steels, during normal cooling, shows the stepped transformation beginning at 700° and 450°. If the temperature be kept at 690° for 18 minutes, the transformation wholly takes place as this temperature and the lower transformation disappears. If the specimen be cooled to 625°, the first part of the transformation takes place partially and proceeds gradually, but at a lower rate than in the previous case. On lowering the halt temperature to 515° the transformation does not progress at all, hence the first part of the transformation takes place more rapidly as the temperature approaches 700°. In the range of temperatures between 570° and 430° no further transformation can take place and as the halt temperature is still further lowered, the second transformation begins to take place and its velocity slightly increases. The starting temperature of the second transformation decreases during normal cooling as the maximum temperature increases. From this and the other evidence given in the paper it is concluded that the Ar′ transformation is not a different transformation but merely the retarded Ar1 transformation. C. O. B.

2171. *Hydrogen Decarburisation of Carbon Steels.* **C. R. Austin.** (Iron and Steel Inst., J. 105. pp. 93–142; Disc., 143–155, 1922.)—Gives details of an investigation into the removal of carbon from fairly pure carbon steels by means of hydrogen at normal pressure and varying temperatures and on the configuration of the recrystallised ferrite grains constituting the decarburised portions. The effect of temperature on the partially decarburised steels is described in the case of three steels containing respectively 0·40, 0·99, and 1·27 per. cent. carbon for temperature ranges of 680° to 1000° C. and it is shown that, with a constant time factor, the maximum range of any partial decarburisation depends on the temperature and on the original percentage of carbon contained in the steel. The effect of time, with a constant temperature, on the amount of decarburisation is also shown and a comparison is drawn between the results obtained and those provided by analogous considerations of the process of cementation. The structure of the carbon-free periphery is profoundly affected by the initial carbon content of the steels when the decarburisation is effected at subeutectoid temperatures, a columnar structure being developed at such temperatures only in the case of the higher carbon samples. Results are given of the effect of temperature on the rate of diffusion of carbon in iron, the medium employed being a partially decarburised hypereutectoid steel and the results show that below the Ac$_3$ inversion diffusion is very slow, but that during a treatment in vacuo for 72 hours at a temperature of 620–650, true diffusion does occur. It is concluded that α-iron must have a real solubility for carbon or carbide of iron and that the degree of solubility depends on the temperature. Approximate figures for the diffusion constant or specific diffusive rate of carbon in iron, based on the application of Fick's law of diffusion are given, viz. at 650° $D = 0{\cdot}005$ at 850° $D = 0{\cdot}05$. Decarburisation by means of pure dry hydrogen is briefly described, and it is shown that under the conditions of the experiment dry hydrogen is not inferior to the moist gas in its efficiency as a decarburising agent; these experiments also indicate that the presence of oxygen is not essential for the production of the peculiar columnar feature of the crystal grains. An experiment on decarburisation with a temperature gradient maintained along a steel specimen has provided an example of decarburisation preceded by carburisation in the same furnace and under similar conditions. C. O. B.

2172. *Chemical Behaviour of Crystallised Binary Compounds, One Component of which is nobler than Hydrogen.* **G. Tammann.** (Zeits. anorg. Chem. 118. pp. 93–104, Aug. 8, 1921.)—A general discussion of the author's views on mixed crystals and compounds and their chemical and electrochemical behaviour. When alloys have been formed by fusion and have been tempered, the two kinds of atoms will be in a normal, regular distribution and will behave like the one or the other component according to their proportions; the respective molar fractions will generally be multiples of ⅛. But exchange of kations with the electrolyte and other factors complicate the phenomena. The examples are taken from Puschin's studies of Pb-Pd (4 compounds), Kremann's studies of Cd-Sb and from a great many other binary compounds, both those in which only one constituent is nobler than hydrogen (*e.g.*, alloys of gold with Mg, Zn, etc., of Ag, Cu, sulphides, selenides, carbides, etc.), and those in which both constituents decompose water (*e.g.*, K-Zn, Na-Bi, Ca-Tl, etc.). So far no binary compound has been shown to be more noble than its nobler component; but potential measurements are sometimes uncertain. On the other hand, there are compounds both the components of which are more noble than hydrogen, and which are yet strongly corroded by aqueous vapour. Thus Cu_2Sb and Cu_3Sb crumble into black powders in moist air, in which Cu_3Si decays slowly (one lump of 20 gm. did so in 4 years) into silica and unoxidised copper. The less noble the active component, the more atoms of the inactive component are needed for its protection. Within the temperature range in which the atoms only oscillate about their lattice points, the affinities are electric in character; otherwise intermediate potentials should be observed. In that range the kations are easily exchanged, the anions maintain the lattice. Intermediate potentials appear at temperatures when internal diffusion occurs within the lattice. H. B.

2173. *Peculiarities in the Electric Potentials of some Metals.* **N. R. Dhar.** (Zeits. anorg. Chem. 118. pp. 75–80, Aug. 8, 1921.)—Since the p.d. of zinc in solution of zinc chloride increases with the dilution of the solution, the p.d. should still further increase in pure water (containing no zinc ions) or in indifferent electrolytes; that should hold also for Mg, Cd, Fe, Ni, etc. In the case of copper the p.d. decreases as the dilution of the copper salt, in which the metal is immersed, is increased; in pure water the p.d. should hence be a minimum, and that should apply also to Ag, Au, etc. Extrapolation of Nernst's formula would seem to support these arguments, though they are not essential to the theory. The author's experimental inquiry into these peculiarities was made already in 1913. He found that the p.d. of Zn, Mg, Al, Fe decreases in pure water and in KCl and KNO_3, contrary to what was stated, whilst Ni and Sn show higher p.d. in water than in these salts. In the cases of Sb, Cu, Ag, however, extrapolation of the formula leads to correct values. Peculiarities were also observed in the behaviour of couples like Fe/water or KCl/Al.

H. B.

2174. *Chemical and Electrochemical Behaviour of some Series of Alloys. (Silicides; Alloys of Sb, Tl, Mg.)* **W. Jenge.** (Zeits. anorg. Chem. 118. pp. 105–122, Aug. 8, 1921.)—According to Tammann continuous series of mixed crystals should not differ from compounds at temperatures, at which there is no exchange of position in the space lattice, in so far as one group of these substances will behave like the one component, and the other group like the other. This is on the whole confirmed, for silicides of Co, Ni, Mn when anodes are in contact with halogen, nitrate, and sulphate ions, hydrochloric and sulphuric acid and caustic soda. Of the compounds and corresponding alloys Co_2Si, Co_3Si_2, CoSi, $CoSi_2$, $CoSi_3$, the higher silicides (CoSi and above) behave like silicon, the others like cobalt, at any rate as long as the reagents are used cold. Of the manganese silicides, Mn_2Si is attacked, the others are not; the Ni-silicides follow the cobalt analogy, but NiSi is attacked. Exposed to the air these silicides with more than 0·25 mol Si assumed the hydrogen potential. Alloys and compounds of Sb with Cd and Zn and of Bi with Tl follow Tammann's rule as to potentials and chemical behaviour; alloys of PbTl behave like thallium when they contain 0 to 0·475 mol Pb, and like lead with higher Pb contents. Alloys of magnesium with Cu, Pb, Cd, Zn, show at first contact with electrolytes the potential of Mg; but they soon assume the lower potential of the more noble metal, and the potential determinations are much influenced by the rapidity of conducting the test and the changes in the exposed surfaces. Alloys consisting of Cu and Cu_2Mg have lower potentials than Cd and Tl, though they precipitate these two metals.

H. B.

2175. *The Normal Potential of Silver.* **I. M. Kolthoff.** (Zeits. anorg. Chem. 119. pp. 202–212, Nov. 3, 1921.)—The normal silver potential of Lewis, $\epsilon_H = -0 \cdot 798$ volt (against hydrogen electrode) differs from that of Neumann, $-0 \cdot 792$, and from Wilsmore's means of various determinations, 0·771. Lewis worked with a silver nitrate concentration of 0·1 N. The author's silver nitrate concentrations range from 0·001 up to 0·1 N; he finds $\epsilon_H = -0 \cdot 7887$ volt; solution of KCl (better than ammonium or potassium nitrate) is interposed between the silver and calomel electrodes. The silver-potential itself is not influenced by KNO_3 solution up to 0·5 N, and very diluted silver nitrate solutions, which behaved somewhat erratically, gave correct values in the presence of a little potassium nitrate. Details of determinations made with silver-colour bromide electrodes are also given; the solubility of AgBr is $4 \cdot 1 \times 10^{-13}$ at 18°; traces of alkali sulphate made the Br′ concentration too small. All the experiments were conducted at 18°. H. B.

2176. *Electromotive Behaviour of Metallic Compounds showing Electronic Conductivity.* **G. Trümpler.** (Zeits. phys. Chem. 99. pp. 9–56, Oct. 25, 1921.)—The author assumes that the outer valency electrons of metals must also be the conductivity electrons because the metallic conductivity disappears when they are bound in compounds. In the heavy metals, in which valencies are indistinct, mixed (electrolytic and metallic) conductivity is known for some sulphides and oxides, the higher oxide generally having the greater conductivity; here the inner electrons also seem to be concerned in the conductivity. The ordinary chemical formulæ do not really accord with our valency notions frequently, and the ammoniates of W. Biltz (Zeits. Elektrochem. 26. p. 347, 1920), like $Ca(NH_3)_6$, form salts as if they were metals. In order to investigate electronic and electrolytic conductivities—the distinction is uncertain in some bad conductors—the author makes p.d. measurements on combinations of a metal serving as conductor and a compound of the same or some other metal with a metalloid against an aqueous solution in which the two components are present as ions and the metalloid may be present. In the system A, i.e. $Pb/PbS/PbNO_3$(sat.)/Pb, the e.m.f. will be zero, if PbS be an electrolyte. If PbS be a metallic conductor, no *a priori* statement can be made, but the author shows that the e.m.f. should again be 0. In case B (the negative constituent present in the solution as free ion): Pb/PbS solid/Na_2S. PbS saturated/Pt, the character of the conductivity, metallic or electrolytic, should make a difference in the e.m.f. Details are given of experiments made with sulphides (lead, silver, cupric, cuprous, ferrous) in solutions of sodium sulphide and polysulphides, as well as with silver bromide, iodide, etc. The reactions may be complex, and some accepted solubility data are corrected. The measurements render it probable that metallically-conducting solutions will, in a solution, in which the negative component occurs as free ion, also assume the potential of the metallic component, the normal potential varying with the concentration of the negative component. In pure electrolytes the potential is independent of the free negative component. There must hence be a difference in the structure of the two types. Solid electrolytes consist of ions occupying the points of the space lattice. In metallically-conducting compounds the bricks must be the atoms or molecules (not the ions); hence also in these latter compounds there is absence of certain properties in the infra-red which all electrolytes possess. H. B.

2177. *Use of Phthalate Solutions for Hydrogen Electrode Standards.* **E. T. Oakes** and **H. M. Salisbury.** (Am. Chem. Soc., J. 44. pp. 948–951, May, 1922.)—The proposal has been recently made that the calomel electrode be replaced by phthalate solutions as standard hydrogen electrodes. It is found, however, that even the most carefully purified phthalate solutions exhibit progressive decrease in hydrogen-ion concentration when in continued contact with the hydrogen electrode. This decrease in hydrogen-ion concentration is due to a change, probably a reduction, of the phthalate itself. If such charge is caused by the presence of impurities, the latter must act as catalysts in the reduction of the phthalate. T. H. P.

2178. *Effect of Hydrogen Pressure on the Electromotive Force of a Hydrogen-Calomel Cell.* **W. R. Hainsworth** and **D. A. MacInnes.** (Am. Chem. Soc., J. 44. pp. 1021–1032, May, 1922.)—The variation of the e.m.f. of the cell $H_2 \mid HCl(0\cdot1N)HgCl \mid Hg$ at 25° with variation of the pressure of the hydrogen has been investigated for pressures extending to 400 atmos. The experiments of Ellis [Abs. 1091 (1916)] gave results in agreement with the equation, $\Delta E = \frac{RT}{2F} \log p$, ΔE being the change in the e.m.f. of the cell produced by changing the pressure from 1 atmo. to p atmos.; the pressures employed, however, ranged only from 1 to 1·5 atmos. The most complete thermodynamic treatment of the experimental data now rendered available leads to the expression, $\Delta E = 0\cdot02958 \log p + 6\cdot56 \times 10^{-6}(p - 1) + 3\cdot7 \times 10^{-10}(p^2 - 1)$, which does not, however, take account of effects due to the change in volume of the acid solution due to the solubility of the hydrogen; the first term of this equation follows from the expression RT/2F, given above, while the second and third terms attain appreciable magnitude only at comparatively high pressures. The observed and calculated values of ΔE differ by amounts increasing with the pressure, being respectively 0·0787 and 0·0797 volts at 400 atmos. T. H. P.